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A MAGNETIC SURVEY OF NORTH-EAST TRINITY PENINSULA, GRAHAM LAND

II. MOUNT BRANSFIELD AND DUSE BAY TO VICTORY GLACIER

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ABSTRACT

AN area of approximately 1,600 sq. miles (4,140 km.^{2}) of north-east Trinity Peninsula has been surveyed with an Askania vertical magnetic field torsion magnetometer. It is postulated that a batholith of the Andean Intrusive Suite underlies Trinity Peninsula; interpretation of the anomalies produced by variations in the configuration of the batholith's roof has yielded information on general structural trends in this area. The magnetic survey results indicate the existence of a north-west to south-east set of structural trends across Trinity Peninsula, but a combination of geophysical and geological information suggests more general south-west to north-east structural trends parallel to the length of Trinity Peninsula.

CONTENTS

I. INTRODUCTION

THE vertical field magnetic survey of the north-eastern part of Trinity Peninsula (Fig. 1) carried out during 1960–62 was a direct extension of the survey of Tabarin Peninsula and Duse Bay undertaken by J. Ashley in 1959. A magnetic survey involves mapping variations in the Earth's field produced by the differing magnetic properties of various geological formations; the subsequent interpretation of the survey can then yield information on the nature and structure of the formations. The number of stations necessary to map an anomaly was kept to a minimum and careful consideration was given to the likely reliability of an interpretation, which could be affected by uncertainties in station position, topography and irregularities in magnetic properties in the same rock type. Uncertainties in interpretation can arise due to variable rock magnetic properties and these are discussed later. The area surveyed is shown in Fig. 2. The sea areas were surveyed during the winter by travelling on the sea ice.

The survey was directed particularly to the determination of:

i. The extent and configuration of the Andean Intrusive Suite which crops out in this area.
ii. The position and, if possible, the nature of the contact between the Trinity Peninsula Series and the James Ross Island Volcanic Group in the Prince Gustav Channel area.

The commonest rock type exposed in Trinity Peninsula is a series of greywackes and shales, known as the Trinity Peninsula Series. These sediments are intruded in several areas by granites, diorites and gabbros of late Cretaceous to early Tertiary age, known as the Andean Intrusive Suite. Other rocks exposed in Trinity Peninsula are Middle Jurassic sediments and Upper Jurassic volcanic rocks, Miocene basaltic tuff-agglomerates of the James Ross Island Volcanic Group and (?) Cretaceous andesitic flow lavas. In the Prince Gustav Channel area the most important formation is the James Ross Island Volcanic Group. The detailed geology of the area surveyed is discussed on p. 9–11.

The survey technique was essentially the same as that described by Ashley (1962). The main change was an increase in the average station spacing from 0·75 to 1·5 miles (1·2 to 2·4 km.). However, the spacing of the stations was often varied, so that an area could be surveyed using a minimum but adequate number of stations. An Askania Gfz torsion magnetometer was generally used in the field, although an Askania Gf6 magnetometer was used as a substitute for a period of five months. The Gf6 magnetometer was normally used for recording diurnal variations in the vertical magnetic field, but during the period it was used in the field, diurnal variation information was obtained from the Argentine Islands magnetic observatory.

About 1,600 sq. miles (4,140 km.^{2}) were surveyed from a succession of base stations, which were linked together magnetically with maximum possible accuracy. The method of linking base stations was modified when necessary to compromise between weather conditions and survey accuracy, as was the technique for the whole of the survey.

The field magnetic readings require several corrections before they can be assumed to give a representation of the geological structure. The corrections for diurnal variation, temperature variation, instrument drift and regional gradient have been fully discussed by Ashley (1962). These corrections are also referred to on p. 6–9. A comprehensive collection of all rock types exposed in the survey area was made; their remanent magnetizations and magnetic susceptibilities were measured and they are discussed together with measurement techniques on p. 11–16. The interpretation of the data is discussed on p. 16–30.

All the original field data, including the field magnetic readings, plane-table sheets, diurnal variation records and rock specimens are housed in the Department of Geology, University of Birmingham.

II. RECORDING OF DIURNAL VARIATION

THE diurnal variation of the Earth's vertical magnetic field at Hope Bay was continuously recorded using an Askania Gf6 magnetometer with photocell head attachment in conjunction with a Hartmann-Braun dotted line recorder. The non-magnetic hut which housed the instruments, and the techniques for operating these instruments, have been fully described by Ashley (1962). The dotted line recorder printed the relative variations of the Earth's vertical magnetic field at 0·5 min. intervals; the record of diurnal variation appeared as a continuous line when the time variations of the magnetic field were small or "quiet" and as a discontinuous line when the time variations were large or "stormy".

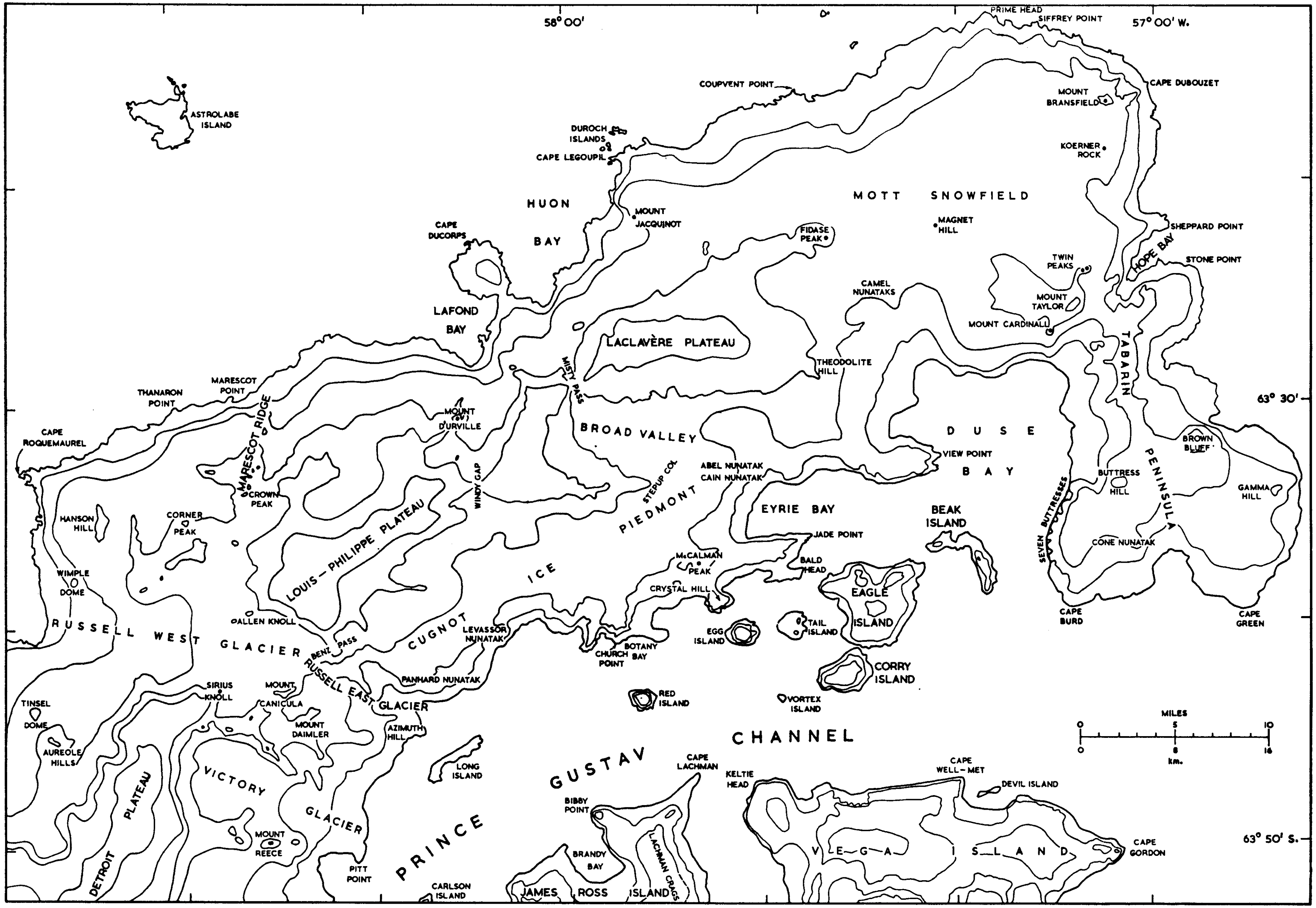

FIGURE 1

Topographic map of north-east Trinity Peninsula. The contour interval is 500 ft. (152 m.).

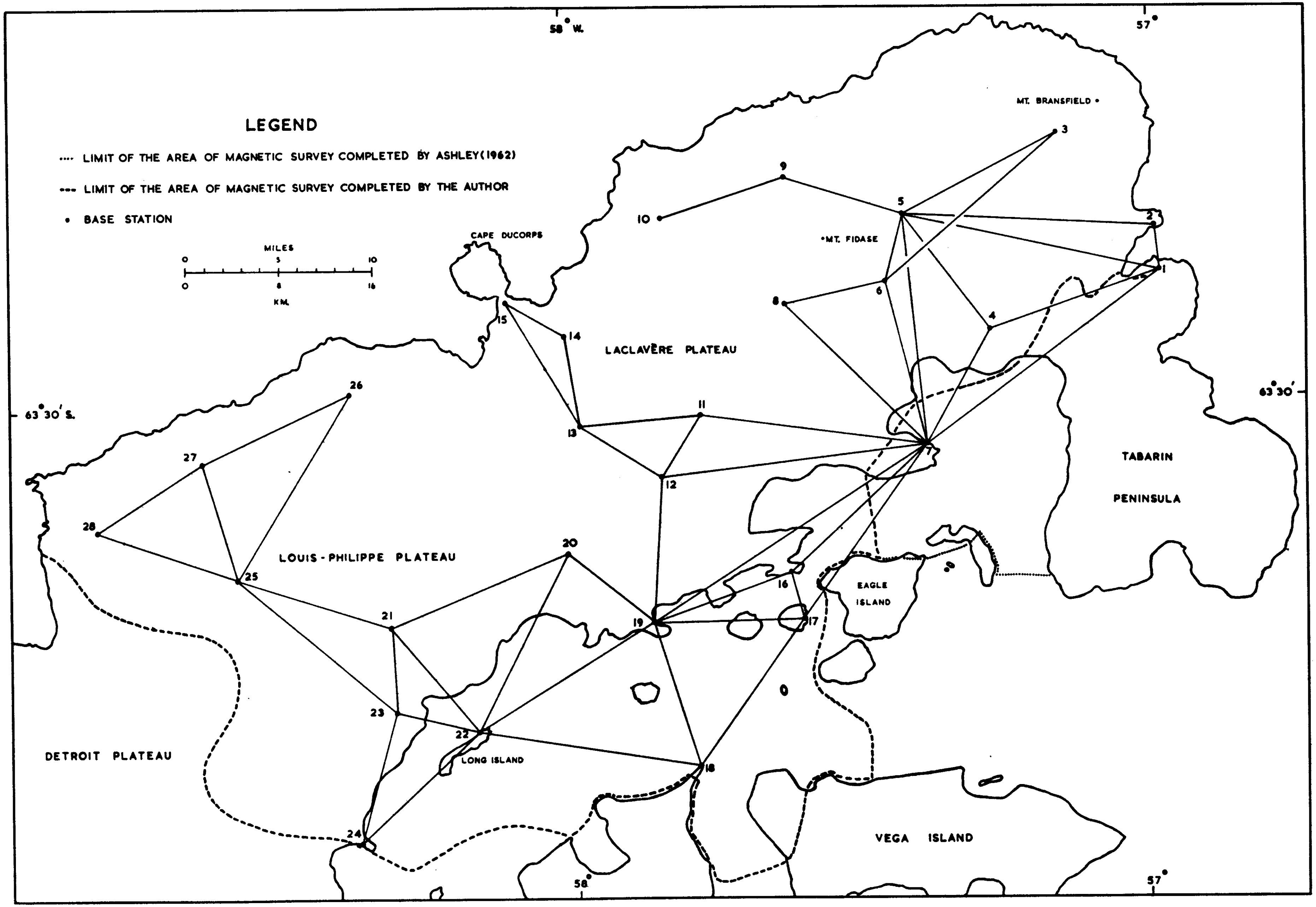

FIGURE 2

Sketch map showing the network of base-station links used in the magnetic survey of north-east Trinity Peninsula.

Ashley (1962) has discussed the magnitude of the diurnal variation in the context of errors which may be introduced into the magnetic survey during diurnal variation correction. The author has used the closure error (the daily difference between the first and final adjusted magnetic field readings for the same base stations) as an estimate of survey accuracy, since the errors in a magnetic survey are governed by factors in addition to the inaccurate application of diurnal corrections.

III. SURVEY TECHNIQUE, CALIBRATION, CORRECTIONS AND ERRORS

1. *Survey of field station positions*

Although the magnetic survey was based on a 1·5 mile (2·4 km.) square grid of stations, the station positions were often varied to accommodate topography, crevasses and the gradient of the magnetic anomalies. Station positions were usually fixed by plane-table resection at a scale of 1 : 100,000 with an accuracy of about 100 m. (328 ft.). Triangulation data, obtained during the 1958–59 topographic survey of Trinity Peninsula, were provided by the Directorate of Overseas Surveys for the preparation of the plane-table sheets. Compass–sledge wheel navigation methods were used when cloud obscured the resection points, only if the magnetic field gradients in the area were sufficiently small. Although the heights of survey stations were measured with an aneroid barometer, the form lines on the existing preliminary maps of the survey area were usually accurate enough for interpretational purposes. It is estimated that the form lines give the heights of the survey stations to an accuracy of 76 m. (250 ft.). Some depth soundings in Prince Gustav Channel and Duse Bay have been recorded by R.R.S. *Shackleton*.

2. *Calibration of field magnetometers*

Three magnetometers were used as field instruments during the course of the magnetic survey. According to the manufacturers, the Askania Gfz torsion magnetometers used in 1960 and 1961–62 had sensitivities of 243·0 and 242·3 gamma/scale degree, respectively. Calibration of the magnetometers gave sensitivities within 1 gamma/scale degree of these values and their use in the calculation of the results would introduce negligible errors in the measured values of the vertical magnetic field over most of the survey area. An error of a few gammas would be introduced by a slight uncertainty in sensitivity in areas of large magnetic field changes, but these errors are insignificant in comparison with the large field changes. Routine adjustments of the instrument levels were made simultaneously with determinations of sensitivity at the beginning and end of each survey journey.

The Askania Gf6 magnetometer, which was used as a field instrument for a short time during 1960, had a constant sensitivity of 25 gamma/scale division.

3. *Correction for diurnal variation*

The Earth's magnetic field varies with time during the course of a magnetic survey. If the area to be surveyed is relatively close to the base diurnal variation recorder, it can be reasonably assumed that the diurnal variations are negligibly different in the two areas. With more distant survey areas the difference between the diurnal variations becomes greater with increasing solar time difference between the two areas (Chapman, 1951, p. 44–46). The correlation between the diurnal variations in two areas also deteriorates with increasing time variation of the magnetic field and with increasing geomagnetic latitude above 60° (Chapman, 1951, p. 89). Although the geomagnetic latitude in north-east Trinity Peninsula is only 54°, it is possible that the disturbed geographical distribution of magnetic field distribution described by Chapman (1951) may already have some significance here.

Although the Askania Gf6 magnetometer was normally used as a base diurnal recorder, its use during 1960 as a field instrument necessitated diurnal variation correction from data obtained at the Argentine Islands magnetic observatory. Applications of different modifications of the time scale and amplitudes of the diurnal variation at the Argentine Islands to the results of the magnetic survey near Hope Bay gave the smallest average daily closure error when neither changes in amplitude nor time scale were made.

Errors associated with the reading of magnetic field values on the diurnal variation record at the time of the field survey observations depend on the rate of change of the diurnal variation. The diurnal variation recording, which is composed of a series of dots of diameter 0·3 mm. recorded with a paper speed of

0·3 mm./min., could only be read accurately to the nearest minute. Ashley (1962) has estimated that the error in reading the diurnal variation record may be as much as 15 gamma during stormy conditions but the magnetic survey was usually suspended when the errors of diurnal variation correction might have reached this magnitude.

4. *Temperature effects on instruments*

a. *Field magnetometers.* The manufacturer's values for the temperature coefficients for the instruments used in the field indicated that temperature variations in the range of −30° to +40°F (−34° to +5°C), which were encountered in the field, would cause errors of less than 1 gamma in the final results.

b. *Diurnal variation magnetometer.* A magnet system with a sensitivity of 10 gamma/scale division was used in the Askania Gf6 magnetometer for recording diurnal variation. This magnet system did not have a temperature coefficient of zero and at the end of 1960 the temperature coefficient was changed from $2·1\pm0·8$ gamma/°F ($3·8\pm1·4$ gamma/°C) to $0·63\pm0·22$ gamma/°F ($1·13\pm0·39$ gamma/°C). Two determinations of the latter value gave the same temperature coefficient within the limits of the standard deviations of the measurements. The temperature variations in the magnetometer hut were usually less than 10°F (5·6°C), so that temperature corrections were never very large.

5. *Closure errors*

During the course of the magnetic survey the field magnetometer was read at the beginning and end of the day at the same base station. The difference between the adjusted values of these first and final readings has already been called the closure error. This error is often attributed to instrument drift, but it is probable that the difference between the diurnal variation at the base recorder and that in the field also contributes to some of the closure errors determined during parts of the survey more distant from Hope Bay.

The average of the daily closure errors for the whole of the survey was 11 gamma. The average daily closure error for the winter (May–August) of 1960 was 9 gamma, but this increased to 14 gamma during the following summer (November–February). This increase can partly be attributed to an increase in the length of a working day, but it is also possible that the more disturbed diurnal variation during the summer months may make the application of diurnal variation corrections obtained at the distant Hope Bay base station less accurate than that during the winter months.

6. *Establishment and adjustment of the base-station network*

If the instrument used for a magnetic survey has a reading which drifts with time, then the survey technique must be designed both to control and determine this drift. The technique of using the same base station at which to begin and end the day's survey gives a daily check on instrument drift. Accurate survey of a large area can be achieved by working from a series of base stations which are then linked together to form a network in which the vertical magnetic field differences between base stations are accurately known. The simplest closed base-station network is built on a series of triangles formed by three links between three base stations.

The distribution of base stations in the area of the present survey is shown in Fig. 2. The base-station network was built on the determinations of magnetic field differences between each of a unit of three base stations. Instrument drift was measured by a determination of the magnetic field at the first base station (A), then at the second (B), and finally at the first once more. The same procedure, or "two-way" link, was repeated for each of the other two base stations, B and C. The algebraic sum of the magnetic field differences between stations A, B and C should be theoretically zero, but there is often a small residual or closure error. Some of the magnetic field differences between base stations on the north coast of Trinity Peninsula were determined by using "one-way" links, so that the instrumental drift was not measured. This less accurate method was only used after many attempts at "two-way" links had been obstructed by bad weather. The complete base-station network was adjusted by a least-squares method devised by Smith (1951), with the "two-way" and "one-way" links given adjustabilities of one and two, respectively, whenever both types of link form part of a triangle within the base-station network. The average closure error for the whole of the base-station network was 12 gamma before least-squares adjustment, whilst that for the base-station network in Prince Gustav Channel was 8 gamma. An indication of the error in each base-station link can be obtained from the total closure error for each triangle in the base-station network, after allowance has been made for the adjustability of each link. The errors given in Table I have been obtained by adding, where necessary, according to the error addition law, i.e. by the addition of variances. The errors for the determination of the magnetic field at each of the base stations have been obtained by the addition of errors for the smallest number of links between that station and the Hope Bay base station.

TABLE I

VALUES FOR MAGNETIC BASE STATIONS

Base Station Number	*Magnetic Field* (gamma)	*Base Station Number*	*Magnetic Field* (gamma)
1*	+200	15	+16±15
2	+319±4	16	+161±6
3	−122±16	17	+2,896±8
4	−86±10	18	+903±8
5	+604±8	19	+361±6
6	−153±6	20	+314±6
7	+1±5	21	+389±8
8	−174±8	22	+515±8
9†	+241	23	+479±10
10†	−101	24	+629±10
11	+12±6	25	+329±21
12	+129±6	26	+186±22
13	+133±15	27	+817±23
14	+37±15	28	+196±36

* Base station number 1 has an arbitrary value of 200 gamma. This was the value given to the vertical magnetic field at the Hope Bay base station by Ashley (1962).

† Errors are not available for stations 9 and 10, because re-location of these stations was not possible after it had become necessary to return to the Hope Bay station.

7. *Removal of the regional gradient of the Earth's magnetic field*

The magnetic field variations, which are observed over the surface of the Earth, result from the superposition of anomalies produced by local geological variations on the Earth's regular (or dipole) field. This field is thought to have its origin within the core of the Earth (Chapman, 1951) and therefore it is unconnected with the magnetic field variations produced by crustal geology. The application of a regional correction separates the Earth's regular field variations, which have low curvature and gradient, from those variations with relatively higher curvature and gradient which have their origin in the Earth's crust.

The selection of the curvature of the regional magnetic field to be applied as a regional correction is somewhat arbitrary. The smallest curvature field variations which could be applied are given in the comprehensive maps published by Vestine and others (1947). Unfortunately, these maps are based on sparse data in the Graham Land area and they may not be too accurate. A total field magnetic survey of the Scotia Sea carried out by the Department of Geology, University of Birmingham, in collaboration with the British Antarctic Survey (Griffiths and others, 1964), has provided a more reliable total field gradient. The constant gradient of the total field on the southern side of Drake Passage, north of Bransfield Strait, has been assumed to continue over the area of north-east Trinity Peninsula. The vertical field gradient has been calculated from the total field gradient by using values of magnetic dip and declination measured at Hope Bay. The magnetic dip has been measured as 56·5° UP (personal communication from D. J. Blundell), and the declination as 13·5° east of true north (personal communication from the Directorate of Overseas Surveys). The values of the northerly and westerly gradients of the regional vertical magnetic field were calculated as:

northerly gradient = −8·1 gamma/km. (−13·0 gamma/mile),
westerly gradient = +3·0 gamma/km. (+4·8 gamma/mile).

A negative northerly gradient of 8·1 gamma/km. (13·0 gamma/mile) implies that the magnitude of the vertical field decreases at this rate in this direction. The strike of the regional vertical magnetic field is 290° east of true north and the gradient is 8·6 gamma/km. (13·8 gamma/mile). The vertical component of the Earth's magnetic field has a direction which is **UP** in the Southern Hemisphere and the convention used by magnetic observatories gives a negative value for this field inclination, i.e. normal vertical magnetic fields are positive and negative in the Northern and Southern Hemispheres, respectively. An increase in the (negative) vertical magnetic field is defined as a positive anomaly on Maps 1 and 2.

A recent analysis of magnetic field data from Antarctica by Nagata (1962) gives a regional vertical magnetic field gradient in north-east Trinity Peninsula of approximately 10 gamma/km. (16 gamma/mile) with a similar strike direction to that given above. This analysis is based on more data than that of Vestine and others (1947) and it compares reasonably with the regional gradient determined from the total field sea magnetic survey. A comparison between these regional fields suggests that an error of about 1 gamma/km. (1·6 gamma/mile) in the regional field gradient is possible and it must be considered during the interpretation of the magnetic survey.

Other methods for the regional correction of the vertical field survey have been considered. The magnetic field over a large part of the survey area had a fairly uniform low gradient. A regional gradient could have been extracted from these data by graphical or mathematical techniques. However, it was decided first to extract the regional magnetic field given above, and then to examine the residual anomalies or magnetic field variations (Maps 1 and 2) for the applicability of further regional corrections. However, an examination of the residual anomaly map indicated that further corrections were unnecessary.

IV. GEOLOGY

THE geology of Graham Land has been described by Adie (1953, 1957*a*, 1964). The exposures in the area of the magnetic survey (Fig. 3) belong to the seven distinct rock groups described below (Table II).

TABLE II

STRATIGRAPHY OF NORTH-EAST TRINITY PENINSULA

QUATERNARY	Recent Pleistocene	Raised beaches, etc.
TERTIARY	Pliocene	Pecten Conglomerate ~~~~~~~~~
	? M. Miocene	James Ross Island Volcanic Group ~~~~~~~~~
	? L. Miocene	Seymour Island Series ~~~~~~~~~
	Late Cretaceous to Early Tertiary	Andean Intrusive Suite (Andersson Nunatak dolerite (?), Mount Bransfield granodiorite and Mount Reece granite)
MESOZOIC	? Upper Cretaceous*	Andesite volcanic flows (near Cape Legoupil and Prime Head)
	? Cretaceous*	Sediments at Cape Legoupil
	Cretaceous (L.-M. Campanian)	Snow Hill Island Series ~~~~~~~~~
	U. Jurassic	Andesite–rhyolite volcanic group
	M. Jurassic	Mount Flora plant beds
PALAEOZOIC	? Carboniferous	Trinity Peninsula Series

* Stratigraphic sub-divisions based on evidence obtained by Halpern (1964).

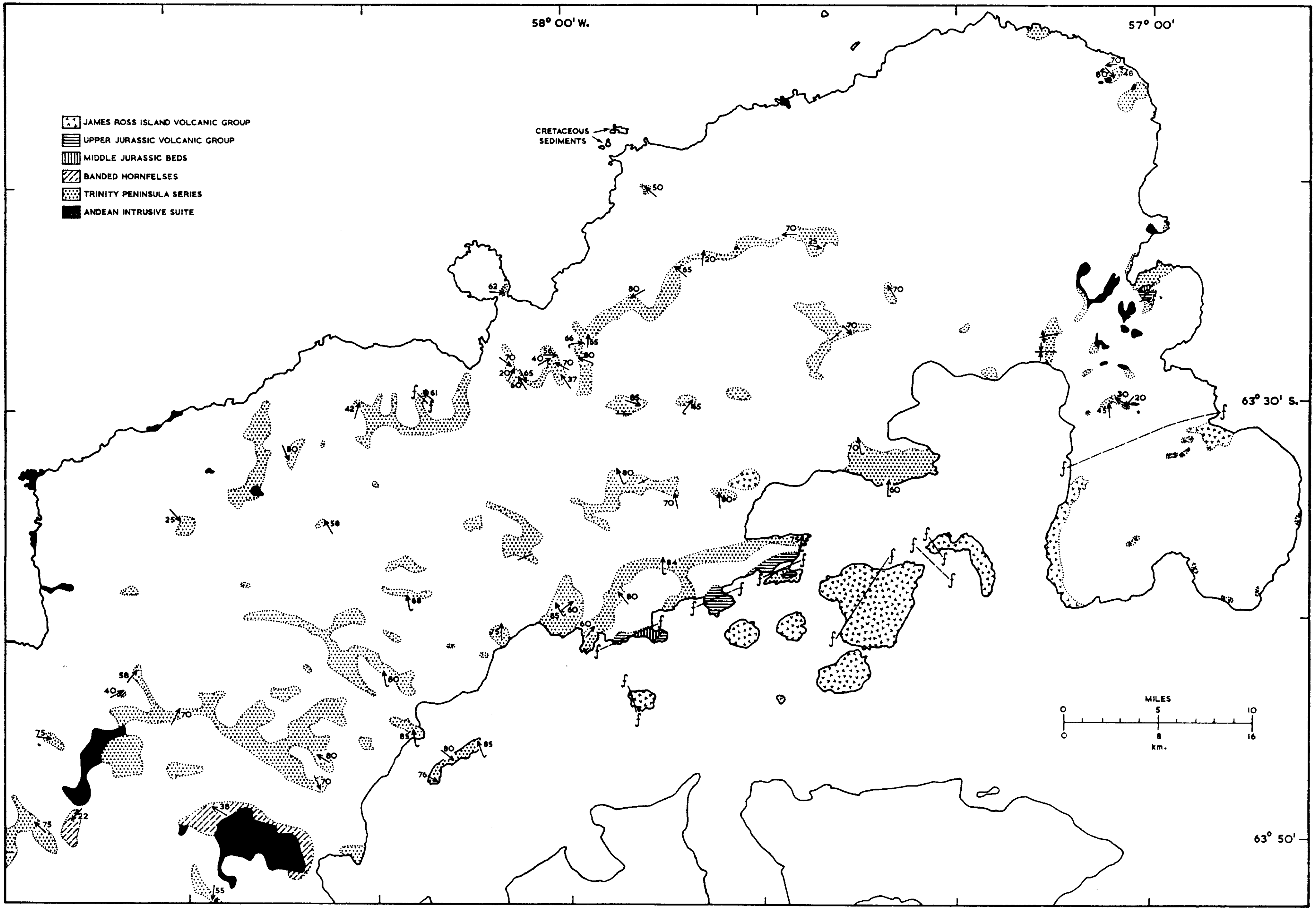

FIGURE 3

Geological sketch map of north-east Trinity Peninsula.

The Trinity Peninsula Series is exposed over large areas and it forms all of the outcrops in the immediate vicinity of both Laclavère and Louis-Philippe Plateaux. These sediments are often thermally metamorphosed where they are in contact with rocks of the Andean Intrusive Suite (Adie, 1957*b*). The thermal metamorphism of the Trinity Peninsula Series increases in intensity towards the east along the north coast of Laclavère Plateau (personal communication from N. Aitkenhead), indicating that the Andean Intrusive Suite rocks may become shallower towards the eastern end of this plateau. The role of thermal metamorphism is more fully discussed in connection with the interpretation of the magnetic survey on p. 20.

Jurassic rocks are exposed along the northern side of Prince Gustav Channel at Camp Hill, Crystal Hill and Bald Head. They are also exposed at Contact Point and Mount Flora in the Hope Bay area, and probably at Koerner Rock (personal communication from D. H. Elliot). Jurassic sedimentary and volcanic rocks are exposed at Camp Hill and Mount Flora, whilst minor intrusions have been observed at Camp Hill (Bibby, 1966). The Middle Jurassic sediments comprise sandstones, conglomerates, breccias, mudstones and shales, which contain abundant plant material (Bibby, 1966). The Upper Jurassic Volcanic Group is composed of tuff-agglomerates, and lavas and tuffs of an andesitic to rhyolitic composition. The narrow well-defined occurrence of Jurassic rocks on the northern side of Prince Gustav Channel has led Bibby (1966) to suggest structural control; he has also suggested that faulting between Camp Hill and Bald Head should be considered as part of a network of faults along Prince Gustav Channel.

The Cretaceous sediments are confined to James Ross, Vega, Snow Hill, Seymour and Cockburn Islands. These sediments consist of conglomerates, grits, shales, mudstones and sandstones, some of which are highly fossiliferous. The only exposure of rocks of probable Cretaceous age on Trinity Peninsula occurs at Prime Head where porphyritic andesitic lava flows are exposed (personal communication from D. H. Elliot). These lavas have been given a tentative Cretaceous age by correlation with similar flows near Cape Legoupil which have been dated by Halpern (1964). The restricted exposure of these rocks along the north coast of Trinity Peninsula may suggest some kind of structural control, and Halpern (1964) has suggested dextral transcurrent faulting between Cape Legoupil and the isthmus south of Cape Ducorps.

Rocks of the Andean Intrusive Suite occur in the northern parts of the area surveyed as granodiorite at Mount Bransfield, quartz-gabbro at Coupvent Point and quartz-diorite at Blade Ridge. The hypersthene-dolerite sill at Andersson Nunatak (personal communication from D. H. Elliot) may not be associated with the Andean Intrusive Suite, but current age determinations should clarify this uncertainty. There are no outcrops of the Andean Intrusive Suite in the Laclavère Plateau and Broad Valley areas, but they appear again farther west at Mount Reece and between Marescot Ridge and Cape Roquemaurel. Apart from the quartz-gabbro at Thanaron Point, the more westerly exposures are usually of a more acid composition than those to the north-east.

The James Ross Island Volcanic Group occurs on James Ross and Vega Islands, where it rests unconformably on Cretaceous sediments, and on Vortex, Carlson, Eagle, Beak, Corry, Egg, Tail and Red Islands, on Tabarin Peninsula and in Broad Valley. This volcanic group comprises an interbedded succession of olivine-basalt lava flows, tuffs and agglomerates. Dyke swarms are particularly evident on Tail and Vortex Islands, whereas dykes are less evident throughout the area of Prince Gustav Channel. Before the discovery of the tuffaceous agglomerates in Broad Valley, the James Ross Island Volcanic Group was only known to occur south-east of an arcuate line through Tabarin Peninsula and Prince Gustav Channel. The geographical isolation of these volcanic rocks led to the inference that there was either an unconformity or faulting between the Trinity Peninsula Series and the James Ross Island Volcanic Group. The discovery of the tuffaceous agglomerates in Broad Valley may have weakened the basis for this inference, but it is still supported by the faulting between Bald Head and Camp Hill, and the physiography of Prince Gustav Channel.

The Pecten Conglomerate of Cockburn Island is the youngest sedimentary succession exposed near the area surveyed.

V. DETERMINATION OF THE MAGNETIC PROPERTIES OF ROCK SPECIMENS

ROCK samples were collected widely over the area of the magnetic survey. Particular attention was given to the collection of rocks with high intensities of magnetization (Ashley, 1962), and therefore nearly all exposures of the Andean Intrusive Suite on Trinity Peninsula were sampled. The greywackes and shales of the Trinity Peninsula Series are effectively non-magnetic, and hence sampling of the widespread outcrops of these rocks was less comprehensive. Most of the exposures of the Upper Jurassic Volcanic Group, the James Ross Island Volcanic Group and the (?) Cretaceous volcanic rocks were also sampled.

Measurements of the remanent magnetizations and susceptibilities of the specimens were made in the Department of Geology, University of Birmingham.

1. *Measurement of remanent magnetization*

The remanent magnetization can be one of several varieties, but the commonest amongst igneous rocks is thermo-remanent. This is acquired during the cooling of the ferromagnesian minerals in the magma below their respective Curie Points. It is retained by the rock unless the minerals themselves are chemically altered.

Specimens of fresh unweathered rock were collected and their *in situ* positions were defined by horizontal lines on two sides and a line indicating magnetic north on the upper surface. The original field orientations of the samples were reproduced in the laboratory by mounting them in plaster of Paris. Cylindrical specimens of diameter 1·9 cm. (0·74 in.) were drilled from the samples and their orientations at the sample localities were marked on the top faces. The specimens were then extracted from the sample blocks and cut to 1·9 cm. (0·74 in.) length. The remanent magnetization of each specimen was measured on either a spinning-type magnetometer or an astatic magnetometer, or both. Usually three specimens from each sample were measured, although the difficulty of coring some of the more friable samples sometimes reduced this figure.

Specimens with relatively strong intensities of remanent magnetization, of the order of 10^{-3} e.m.u./cm.^{3}, were measured on a spinning-type magnetometer (Griffiths, 1955). These measurements were far quicker than those made on the astatic magnetometer and the accuracy of measurement, although not as good, was adequate for the interpretation of the magnetic survey. Measurements of weaker intensities of magnetization and some duplication of the spinning-magnetometer measurements were made on an astatic magnetometer, which was essentially similar in design to that described by Blackett (1952). The duplication of some of the measurements served as a check on the reliability of both measurement techniques.

The astatic magnetometer was calibrated by using an absolute electrical method, whereas the spinning magnetometer was calibrated with respect to the astatic magnetometer by using rock specimens with stable magnetism. All of the specimens of the Andean Intrusive Suite, and some of the Miocene and Upper Jurassic volcanic rocks, were subjected to demagnetization tests in fields up to 200 oersted. The purpose of these tests was, first, to test the stability of the remanent magnetization of the specimen and, secondly, to "wash out" any superficial magnetism of weak stability which might mask the uniformity of the more stable magnetism between similar specimens. It was found that some of the more weakly magnetized granites with random directions of magnetization were unstable, but most of the more strongly magnetized rocks of the Andean Intrusive Suite were found to have stable remanent magnetizations whose directions became more uniform after the demagnetization tests. In all, about 80 specimens were measured and 20 of them were tested for stability. Table III gives the values of remanent magnetization determined in the laboratory.

Some of the rocks measured have reversed directions of remanent magnetization, i.e. they are magnetized in a direction opposed to that of the Earth's present magnetic field. All the Trinity Peninsula Series sediments and the tuffs and agglomerates of the James Ross Island Volcanic Group have low intensities of remanent magnetization. However, Ashley (1962) has collected some greywackes and shales from the Trinity Peninsula Series of Tabarin Peninsula which are relatively strongly magnetized and which show strong thermal metamorphism (Adie, 1957*b*). The remanent magnetism of the Upper Jurassic volcanic rocks has an average intensity of the order of 10^{-4} e.m.u./cm.^{3} and the directions of magnetization are random. Fig. 4 shows the directions of remanent magnetization of the specimens of the Andean Intrusive Suite collected in the area surveyed. The remanent magnetization of the specimens collected at Thanaron Point has a mean azimuth which is significantly different from that of the Andean Intrusive Suite in north-east Trinity Peninsula. The mean direction of remanent magnetization for all the stable rocks of the Andean Intrusive Suite (with the exception of those from Thanaron Point) calculated by averaging

TABLE III

VALUES OF REMANENT MAGNETIZATION

Rock Type	Locality	Number of Specimens	*Intensity of Magnetization*		*Direction of Magnetization*		
			Range of Values (e.m.u./cm.^{3} $\times 10^{-6}$)	*Mean Value* (e.m.u./cm.^{3} $\times 10^{-6}$)	*Declination*	*Inclination*	*Stability**
James Ross Island Volcanic Group							
Tuff agglomerate	Cain Nunatak	1	0	—	—	—	—
	Cain Nunatak	1	26	26	178°	4° **UP**	—
	North Egg Island	1	166	166	195°	6° **UP**	—
	North Egg Island	1	92	92	141°	65° **UP**	—
	Red Island	2	32–431	—	53°, 179°	90°, 89° **DOWN**	—
	South-west Vortex Island	2	16–55	35±17	207°	0° **UP**	—
Tuff	North-east Tail Island	2	15–20	17±2	341°	36° **UP**	—
Olivine-basalt	Tail Island	1	12,380	12,380	319°	72° **UP**	—
	Cape Keltie	2	4,729–6,845	5,787±1,060	39°	53° **UP**	38°, 50° **UP**
	4 miles (6·4 km.) south of Cape Keltie	2	6,826–7,894	7,360±543	283°	81° **DOWN**	285°, 79° **DOWN**
Andean Intrusive Suite							
Granite	Mount Reece	2	0–4	—	—	—	**Unstable**
	Mount Reece	4	0–24	—	0°	0° **UP**	**Unstable**
	1·25 miles (2 km.) north-west of Crown Peak	1	152	152	352°	47° **UP**	**Stable**
	Wimple Dome	2	0–2	—	—	—	**Unstable**
	Wimple Dome	2	2–192	—	318°	67° **UP**	**Unstable**
Granodiorite	Mount Bransfield	6	362–1,377	860±390	356°	62° **UP**	**Stable**
Diorite	Blade Ridge	4	679–1,009	866±135	22°	67° **UP**	2°, 71° **UP**
Quartz-gabbro	Coupvent Point	5	383–565	535±120	346°	54° **UP**	**Stable**
	Thanaron Point	6	1,420–2,604	1,862±150	313°	63° **UP**	313°, 59° **UP**
Upper Jurassic Volcanic Group							
Tuff	Koerner Rock	2	1,183–2,603	1,893±224	293°	26° **UP**	302°, 22° **UP**
Lava	South-west Church Point	4	184–235	247±66	187°, 67°	49°, 70° **UP**	**Unstable**
Andesite?	Camp Hill	2	139–191	165±18	73°	70° **UP**	—
	Crystal Hill	2	0–4	—	—	—	—
	Bald Head	2	166–228	197±31	71°	66° **UP**	—
Acid dyke rock	Striped Hill	2	0	—	—	—	—
Trinity Peninsula Series							
	Various localities	20	0–2	—	—	—	—
Other igneous rocks							
Hypersthene-dolerite	Andersson Nunatak	2	377–469	423±56	217°	60° **DOWN**	221°, 55° **DOWN**
Porphyritic andesite	Prime Head	1	652	652	75°	69° **UP**	57°, 82° **UP**

* The comments under the heading "Stability" are the results of tests in demagnetizing fields of up to 200 oersted. Where the new direction of magnetization is substantially the same as before demagnetization, the specimen is tabulated as "stable", but when the direction of magnetization is widely different the specimen is tabulated as "unstable". For changes in the direction of magnetization intermediate between these two extremes the direction after partial demagnetization is given.

the direction cosines, has a declination of 353° east of magnetic north and an inclination of 60° **UP**. An estimate of the probable accuracy of the calculated mean direction of remanent magnetization for these rocks can be obtained using the statistical method of analysis devised by Fisher (1953). It has been calculated that there is a 95 per cent probability that the average direction of remanent magnetization will be within 5° of the calculated mean direction.

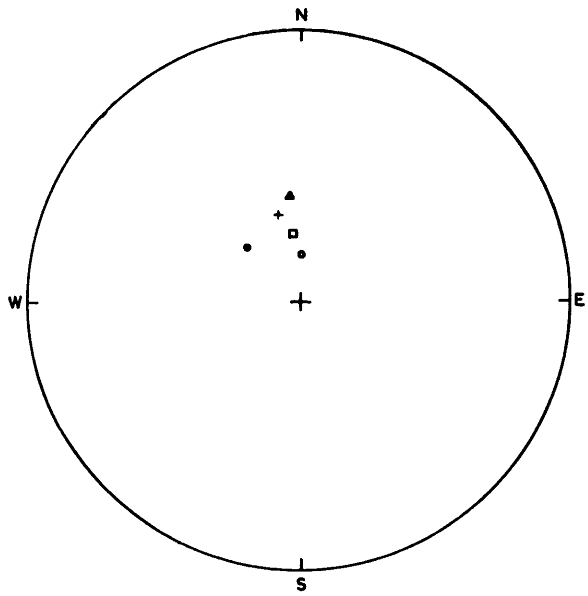

FIGURE 4

Stereogram showing the average direction of remanent magnetization of rock samples from various sites.

- ▲ Granite from 1·25 miles (2 km.) north-west of Crown Peak.
- □ Granodiorite from the Mount Bransfield area.
- o Quartz-diorite from Blade Ridge.
- + Quartz-gabbro from Coupvent Point.
- ● Quartz-gabbro from Thanaron Point.

The remanent magnetization inclination of 60° **UP** is low, since for these latitudes the inclination of the axial dipole field is 76° **UP** (Ashley, 1962). This discrepancy could be explained in several ways. First, the original remanent magnetization of the Andean Intrusive Suite may not have been completely stable and its direction may have moved round towards the Earth's present field direction. However, this seems unlikely, since laboratory tests have shown that the direction of remanent magnetization for the strongly magnetized rocks is stable in demagnetizing fields up to 200 oersted. Secondly, it may be that the scale of sampling has not averaged out variations in the direction of remanent magnetization which were caused by the secular variation of the Earth's magnetic field at the time of the intrusion. The intrusions at each of the sampled sites must have had slightly different times of cooling, and it is possible that they were small compared with the period of the secular variation. The mean direction of remanent magnetization would then be different from that obtained for the type and age of rock in the area; this explanation seems unlikely, if it is considered in the context of the palaeomagnetic investigations carried out in Graham Land by Blundell (1962). He obtained no discrepancies of the scale given above which might have been produced by secular variation. Thirdly, it might be that after the emplacement of the Andean Intrusive Suite in this area there was a rotational movement which may have been associated with large-scale tectonic movements. The possibilities of post-formational movement are discussed in conjunction with the interpretation of the magnetic survey (p. 31).

2. *Measurement of induced magnetization*

Any rock containing ferromagnesian minerals will acquire an induced magnetization in the presence of an external magnetic field, which is aligned in the direction of the inducing field (the Earth's magnetic field), and its intensity (I) is given by $I = kH$, where k is the susceptibility of the rock and H is the magnitude of the Earth's magnetic field. The susceptibilities of about 80 specimens were measured by a technique based on that of Bruckshaw and Robertson (1948). The susceptibilities were measured in an alternating magnetic field of peak value 0·5 oersted; the apparatus was calibrated by an electrical method and by using standard salts of known susceptibility. Values of susceptibility are given in Table IV.

TABLE IV

VALUES OF VOLUME SUSCEPTIBILITY

Rock Type	*Locality*	*Number of Specimens*	*Range of Volume Susceptibility* (c.g.s. units/cm.$^3 \times 10^{-6}$)	*Mean Value of Volume Susceptibility* (c.g.s. units/cm.$^3 \times 10^{-6}$)
James Ross Island Volcanic Group				
Olivine-basalt	Tail Island	2	103–258	180±78
	Cape Keltie	2	202–276	239±37
	4 miles (6·4 km.) south of Cape Keltie	2	718	718±0
Tuff agglomerate	Egg Island	2	70	70±0
	Egg Island	2	92–147	119±27
	Cain Nunatak	1	79	79
	Red Island	2	39–70	54±26
	Tail Island	2	50–66	58±8
	Vortex Island	2	28–35	32±3
Andean Intrusive Suite				
Granite	Mount Reece	5	6–13	9±2
	Mount Reece	5	20–26	22±2
	1·25 miles (2 km.) north-west of Crown Peak	1	1,288	1,288
	Wimple Dome	2	28–37	32±2
	Young Point	1	4,784	4,784
Granodiorite	Mount Bransfield	6	6,800–14,720	10,760±397
Diorite	Blade Ridge	4	6,060–8,460	7,170±874
Quartz-gabbro	Coupvent Point	5	5,520–6,808	5,888±162
	Thanaron Point	6	2,208–4,416	3,222±267
Basic dyke rock	Young Point	3	11,408–13,980	12,760±1,060
Upper Jurassic Volcanic Group				
Tuff	Koerner Rock	3	294–7,360	2,650±3,300
	Church Point	5	202–294	246±40
Lava	Camp Hill	3	62–165	112±43
	Crystal Hill	2	28–70	49±21
	Bald Head	2	368–662	515±147
Acid dyke rock	Striped Hill	3	28–49	39±7
Trinity Peninsula Series				
Greywackes	Various localities	20	7–55	35±17
Other igneous rocks				
Dolerite	Andersson Nunatak	3	147–202	171±25
Porphyritic andesite	Prime Head	1	2,950	2,950

The rocks of the Andean Intrusive Suite have a very variable susceptibility, which ranges from very low at Wimple Dome to high in the Mount Bransfield area. Fortunately, for the interpretation of most of the anomalies caused by the Andean Intrusive Suite, the magnetic properties of the intrusion in the Mount Bransfield—Blade Ridge—Coupvent Point area are fairly uniform. However, complications arise in the interpretation of the anomalies in the Cape Roquemaurel—Marescot Ridge area, since there is considerable variation between both the susceptibilities and remanent magnetizations of the quartz-gabbro of Thanaron Point and the granite of Wimple Dome.

The James Ross Island Volcanic Group tuffs and agglomerates, and the greywackes and shales of the Trinity Peninsula Series, have very low susceptibilities. The James Ross Island Volcanic Group lavas and dykes have slightly higher susceptibilities, of the order of 10^{-4} c.g.s. units. A comparison between

Tables III and IV shows that the remanent magnetization usually has the same order of magnitude as the susceptibilities for each specimen. However, the James Ross Island Volcanic Group basaltic lavas and dykes are an exception to this rule, since they have a relatively lower value of susceptibility, and therefore a high value for the ratio of remanent to induced magnetization. This is known as the Koenisberger Ratio, and Koenisberger (1938) has shown that this ratio for lavas can occasionally be anomalously high (of the order of tens), whilst the values for intrusive rocks are usually about unity.

3. *Combination of the remanent and induced magnetizations*

The remanent magnetizations of the various rock groups must be combined with their respective induced magnetizations to obtain resultant magnetizations for use in the interpretation of the magnetic anomalies (Green, 1960). The induced magnetizations were obtained by using a value of 41,600 gamma (1 oersted $= 10^5$ gamma) for the intensity of the Earth's magnetic field, and they were then added vectorially to the remanent magnetizations to obtain the resultant magnetizations. The values of the resultant magnetizations used in the different sections of the interpretation are given in those sections.

VI. INTERPRETATION

1. *Qualitative observations on the magnetic anomalies*

Three types of anomaly characteristic can be observed on the map of residual anomalies (Maps 1 and 2), which has been obtained by correction for the regional variations of the vertical magnetic field.

i. The large variations in positive anomaly, which are observed in the area of north-east Trinity Peninsula where rocks of the Andean Intrusive Suite are exposed.
ii. The anomalies of low gradient and magnitude in the Mount Fidase—Marescot Ridge area, where exposures of the rocks of the Andean Intrusive Suite are absent.
iii. The positive and negative anomalies of moderate or high magnitude and gradient, which are associated with rocks of the James Ross Island Volcanic Group in the area of Prince Gustav Channel.

The anomalies in the northern areas of Trinity Peninsula, and between Cape Roquemaurel and Marescot Ridge, are associated with and produced by the rocks of the Andean Intrusive Suite. Exposures in these areas are generally of quartz-diorite, quartz-gabbro or granodiorite, and laboratory measurements of their magnetic properties confirm that they can produce the high anomalies observed in the field. The changes observed in the magnetic properties of the Andean Intrusive Suite in the Marescot Ridge and Wimple Dome areas suggest that any interpretation of the observed anomalies in this area may be subject to errors caused by unseen variations in magnetic properties.

The area between Mount Fidase and Marescot Ridge is characterized by low-relief magnetic anomalies, which indicate that there are no shallow occurrences of the Andean Intrusive Suite with magnetic properties similar to those observed in the north-east of this area. The exposures here are almost exclusively confined to the greywackes and shales of the Trinity Peninsula Series.

The high magnitudes and gradients of the anomalies in the Prince Gustav Channel area are associated with the James Ross Island Volcanic Group. The large variations in the magnetic properties of the rocks of this group can sometimes make reliable interpretation of the observed anomalies difficult.

2. *Technique and limitations of magnetic survey interpretation*

A method devised by Pirson (1940) for the calculation of the magnetic anomalies produced by both horizontal and vertical polarization of three-dimensional bodies has been chosen as the main interpretation technique. This method is essentially similar to that used by Ashley (1962), but it involves the use of two graticules for the calculation of the vertical field anomalies produced by the two polarizations. Graticules were constructed and checked against anomalies calculated for simple geometrical bodies; apart from the use of some mathematical formulae and depth rules, they were used for the whole of the interpretation. An average inclination of 60° **UP** for the resultant magnetization of the rocks of the Andean Intrusive Suite necessitated consideration of both horizontal and vertical polarizations, since horizontal polarization of the intrusions or magnetic bodies might produce up to 30 per cent of the observed vertical field anomalies.

Magnetic survey alone cannot give a unique solution for the geological structure or the feature producing the observed anomalies, because these anomalies could be produced by an infinite number of configurations of the rocks responsible for the anomalies. However, a reliable solution can often be obtained from the observed anomalies, if the magnetic properties of the rocks are known and detailed information on the geology and topography (this is important when the source of the anomaly is shallow) of the area are available.

3. *Fundamental geological considerations*

Available geological evidence (Adie, 1955) indicates that the batholiths of the Andean Intrusive Suite of South America are similar in petrographic and structural characteristics to the Andean Intrusive Suite of Graham Land. The Andean mountain chain is known to be intruded by a series of batholiths and a similar structure has been inferred for Graham Land (Adie, 1955). The size of the area of high magnetic anomalies associated with the exposures of the Andean Intrusive Suite in north-east Trinity Peninsula suggests that they form part of a major intrusion which may be continuous over the area of the magnetic survey, but there is no geophysical evidence to distinguish between the possibility of the intrusion being either a laccolith or a batholith. However, measurements of the intensity of magnetization of the rocks of the Andean Intrusive Suite indicate that the observed anomalies could only be consistent with a laccolith, if its bottom surface were at least about 10 km. (6·2 miles) deep under the shallowest parts of the intrusion. There is no *a priori* reason for the postulate of a laccolith in preference to a batholith, and in fact a batholith has already been considered more feasible because of the similarities between the intrusive rocks of Graham Land and those of South America. Consequently, the magnetic anomalies associated with the rocks of the Andean Intrusive Suite have been interpreted in terms of topographic variations on the roof of a batholith which is continuous over the area.

Ice thicknesses throughout the area of the magnetic survey are often unknown and they may be up to several hundred feet in places. It is only in certain areas that anything more than a guess can be made at their magnitudes. Both ice and the sediments of the Trinity Peninsula Series may overlie the deeper parts of the Andean batholith roof. Because the greywackes and shales of the Trinity Peninsula Series have a negligible magnetization, it is not possible to delineate the contact between the ice and the sediments.

4. *Topography of the Andean Intrusive Suite rocks in the Mott Snowfield area*

The Andean Intrusive Suite occurs as granodiorite at several localities in the Mount Bransfield area, and the magnetic anomalies associated with these rocks reach a maximum at a small exposure about 4 km. (2·5 miles) north of Mount Bransfield. The anomaly map (Map 2) also shows high-magnitude anomalies to the north and north-west of Magnet Hill and at Coupvent Point, where there is quartz-gabbro of the Andean Intrusive Suite. Another high-anomaly area occurs in the vicinity of Blade Ridge, where quartz-diorite forms the northernmost exposure of the intrusion on Tabarin Peninsula already surveyed by Ashley (1962).

Greywackes and shales of the Trinity Peninsula Series are exposed at Twin Peaks, Mount Fidase, Cape Siffrey, Camel Nunataks and near Mount Bransfield, where there is a contact between the sedimentary and intrusive rocks. The Trinity Peninsula Series at Camel Nunataks shows slight metamorphism, and similar rocks along the north side of Laclavère Plateau exhibit thermal metamorphism, the degree of which increases towards the east (personal communication from N. Aitkenhead) and may suggest that the rocks of the Andean Intrusive Suite are shallower towards the east. Other rocks exposed in this area are the andesitic lavas at Prime Head, which have been given a tentative Cretaceous age by correlation with similar flows observed near Cape Legoupil by Halpern (1964), and the possibly Jurassic tuffs which are present at Koerner Rock and Contact Point (Hooper, 1955). Almost all of this area is ice-covered and it slopes gently down from a low ridge between Magnet Hill and Mount Bransfield. There is little indication of the ice thicknesses over most of this area, although several ice domes and the topography of Magnet Hill suggest that thicknesses can be no more than several tens of feet in these areas.

Measurements of the susceptibility and remanent magnetization of the rock samples collected from Mount Bransfield, Blade Ridge and Coupvent Point gave resultant intensities of magnetization of 5,340, 3,515 and $3{,}320 \times 10^{-6}$ c.g.s. units, which have a mean and standard deviation of $4{,}060 \times 10^{-6}$ and 860×10^{-6} c.g.s. units. The direction of resultant magnetization is in the direction of the Earth's present magnetic field. Four profiles have been drawn across this area and the topographic variations in the roof of the Andean Intrusive Suite batholith have been determined by using both horizontal and vertical polarizations for all the profiles, with the exception of profile C. The magnetic anomalies at profile C have a magnetic north—south trend at right-angles to the profile orientation, so that the vertical field magnetic anomalies produced by horizontal polarization are negligible.

a. *Profile A*. This profile extends from 2 km. (1·2 miles) east of Camel Nunataks to 4 km. (2·5 miles) north-north-west of Mount Bransfield (Fig. 5). Vertical field magnetic anomalies were calculated at

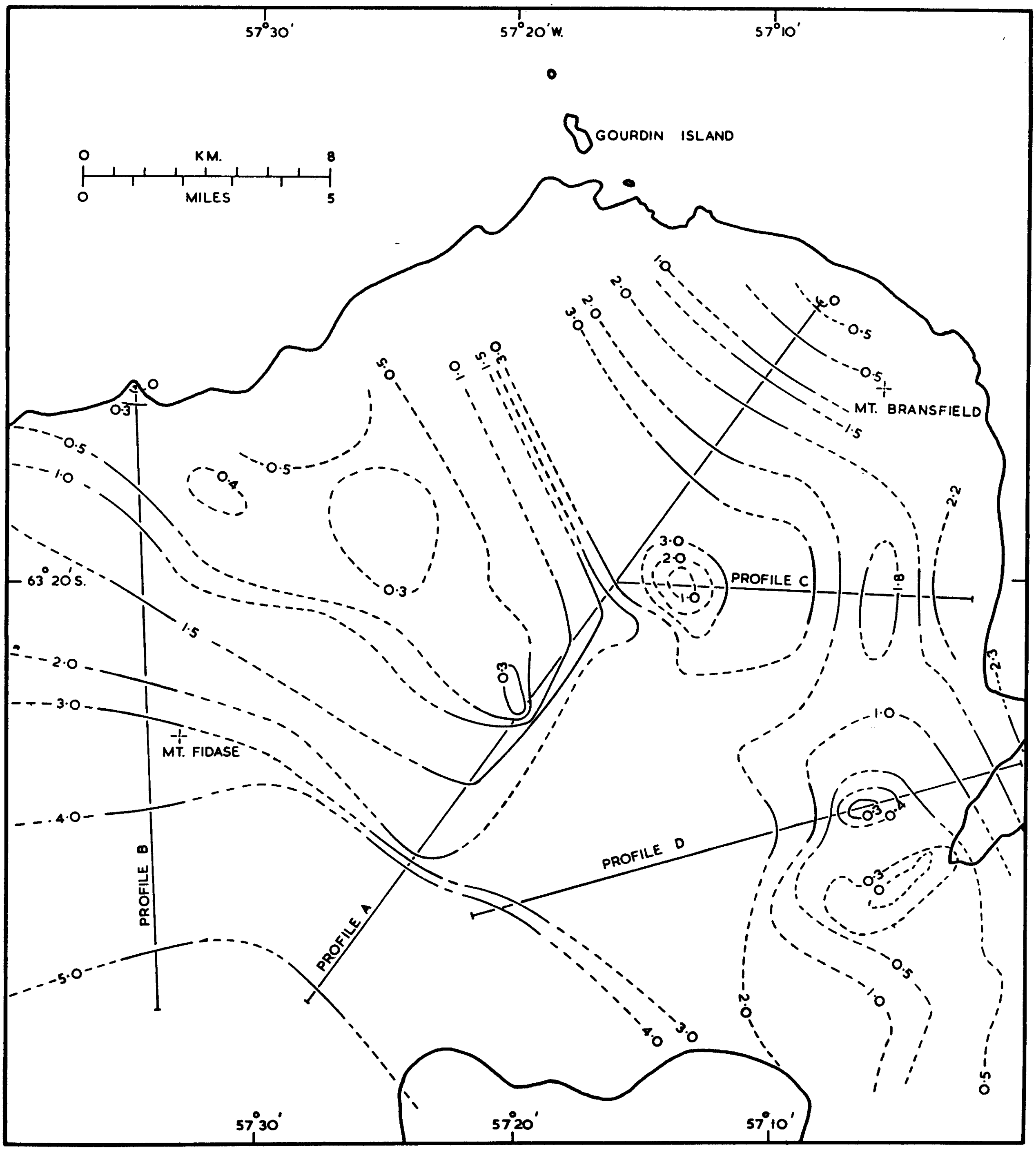

FIGURE 5

Depths (in km.) of the batholith roof (below ground surface) in the Mott Snowfield area, determined from profiles A to D.

several points along the profile, using horizontal and vertical polarizations derived from a resultant intensity of magnetization of $4{,}060 \times 10^{-6}$ c.g.s. units and a contour map of the top surface of the batholith, which was gradually refined until the calculated anomalies approached the observed anomalies. The cross-section of the topographic variations in the batholith roof, and the observed and calculated anomalies are shown in Fig. 6. A depth of 250 m. (820 ft.) was calculated for the shallowest parts of the intrusion

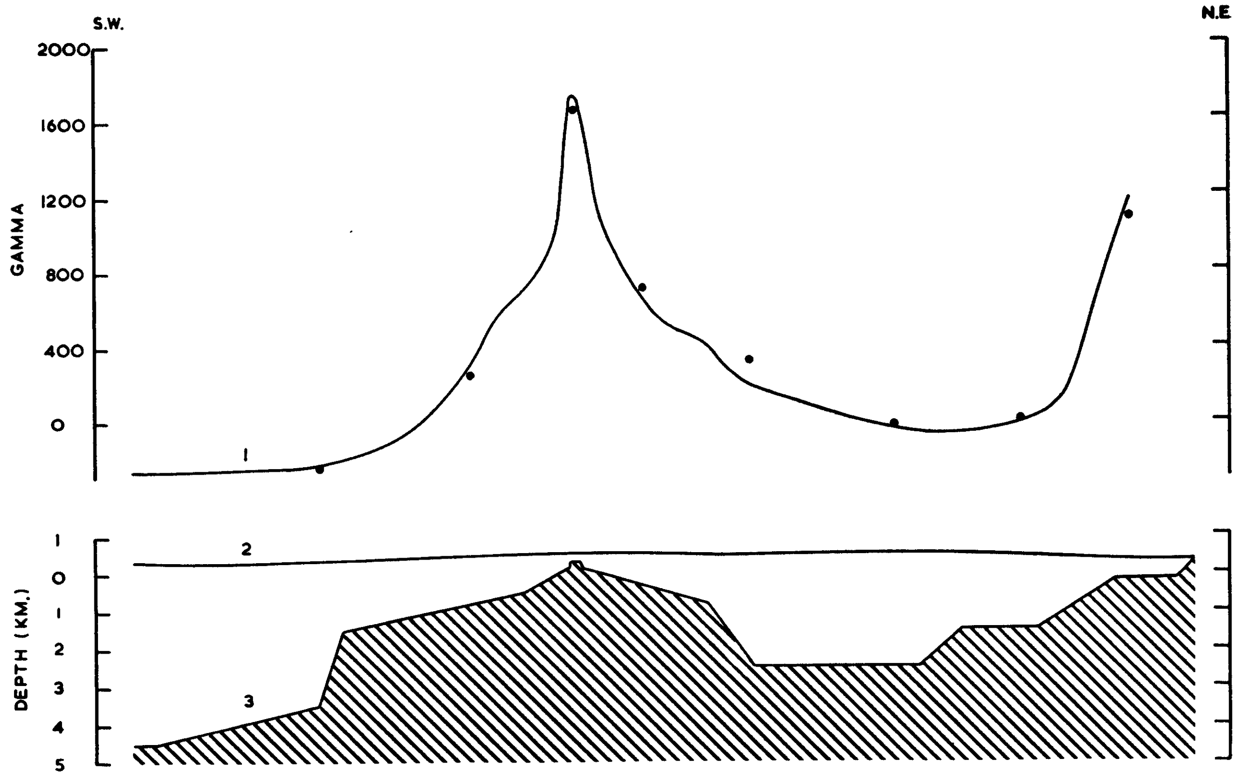

FIGURE 6

Profile A for the solution of the intrusion anomaly.

1. Observed magnetic anomaly.
2. Ground surface.
3. Calculated batholith roof. The intrusion is shaded.

● calculated values of the magnetic anomaly.

near Magnet Hill by using the empirical depth rules of Peters (1949) and Dobrin (1960). It is estimated that this depth, although approximate, must lie in the range of 100–400 m. (328–1,312 ft.). About 10 km. (6·2 miles) east of this dome in the batholith roof, the upper surface of the intrusion plunges to a depth of 2·5 km. (1·55 miles) below sea-level (Figs. 5 and 6), and the strike of the magnetic anomalies associated with this topographic feature is from north-west to south-east. The increase in depth of the batholith roof is shown in Fig. 6 as a series of topographic steps, but it should be emphasized that this topography is not necessarily unique and that other models could be made to fit the magnetic anomalies observed in this area.

There is another sharp decrease in the observed magnetic anomalies at the western end of profile A; this has been interpreted in terms of an increase in the depth of the batholith roof in this area. The steep contact between the intrusion and what are probably greywackes and shales of the Trinity Peninsula Series occurs about 6 km. (3·7 miles) west of the shallowest part of the batholith roof in the Magnet Hill area. This contact has a similar north-west to south-east trend to that of the feature between Mount Bransfield and Magnet Hill, and the batholith roof again deepens by about 2 km. (1·2 miles) with a dip of approximately 70°. The parallelism of these north-west to south-east trending features could have structural implications, and it is suggested that the topographic variations in the batholith roof can be explained in terms of block faulting which occurred during or after the emplacement of the Andean Intrusive Suite.

The magnetic effects of the thermally metamorphosed sediments of the Trinity Peninsula Series have been neglected in the interpretation, because they are small and because the geological control of the interpretation does not warrant such a refinement. Jaeger (1957) has indicated that a thickness of about 100 m. (328 ft.) of greywackes and shales would exhibit a thermo-remanent magnetization comparable with that of the Andean Intrusive Suite. However, some of the rocks of the Trinity Peninsula Series exhibit a low or medium grade of thermal metamorphism, although their remanent magnetization is negligible. For example, the greywackes of Camel Nunataks have an intensity of remanent magnetization less than 20×10^{-6} c.g.s. units and a medium grade of thermal metamorphism (personal communication from N. Aitkenhead), although the calculated distance of these rocks from the batholith roof is 2·7 km. (1·7 miles).

b. *Profile B.* This profile extends from near Mount Fidase in the south to Coupvent Point in the north (Fig. 5). Quartz-gabbros of the Andean Intrusive Suite are exposed at Coupvent Point, but the rest of the profile is ice-covered apart from the Trinity Peninsula Series outcrops in the vicinity of Mount Fidase. It has been calculated that the roof of the intrusion is 3·5 km. (2·2 miles) below sea-level or 4·0 km. (2·5 miles) below the greywackes and shales at Mount Fidase (Fig. 7), using a resultant intensity of magnetization of $4{,}060 \times 10^{-6}$ c.g.s. units. The Trinity Peninsula Series of the Mount Fidase area shows

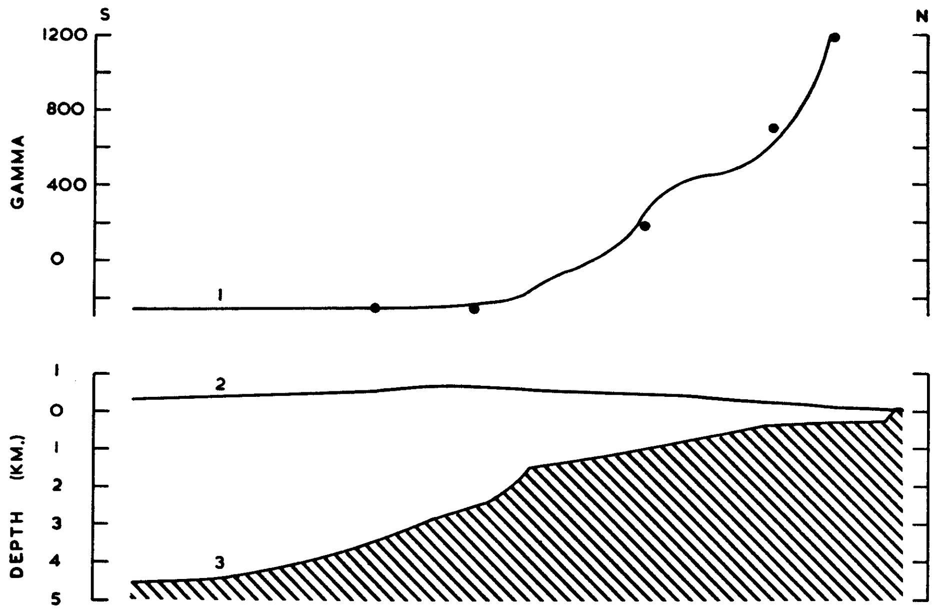

FIGURE 7

Profile B for the solution of the intrusion anomaly.
1. Observed magnetic anomaly.
2. Ground surface.
3. Calculated batholith roof. The intrusion is shaded.
● Calculated values of the magnetic anomaly.

thermal metamorphism of a grade about the same or slightly less than the rocks of Camel Nunataks (personal communication from N. Aitkenhead). The grades of thermal metamorphism and the depths of the batholith roof below the surface in the Mount Fidase and Camel Nunataks areas would therefore appear to be consistent.

c. *Profile C.* The magnetic anomaly map (Map 2) shows a high anomaly in the area of Blade Ridge and Twin Peaks, and an anomaly ridge stretching north towards Mount Bransfield, which may be indicative of a possible connection at depth between the exposures of the Andean Intrusive Suite at Mount Bransfield and Blade Ridge. Profile C was drawn to delineate this connection and Fig. 8 shows the section interpreted from the observed anomalies, using a resultant magnetization with an intensity of $4{,}060 \times 10^{-6}$ c.g.s. units in the direction of the Earth's magnetic field. Two features are prominent on this profile and the eastern of the two is the suggested ridge in the batholith roof, which has a depth of 1·5 km. (0·9 miles) below sea-level. The western feature is an eastward extension of the shallower parts of the batholith roof and should not be given too much importance, since it is based on only one magnetic observation. This feature takes the form of a ridge on this profile, although it appears as a dome on the contour map of the batholith roof (Fig. 5).

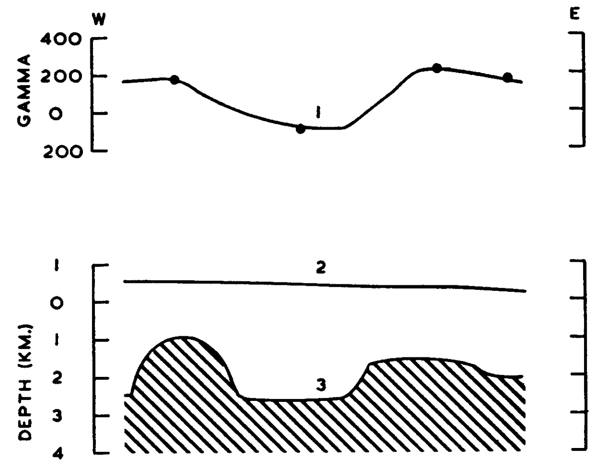

FIGURE 8

Profile C for the solution of the intrusion anomaly.
1. Observed magnetic anomaly.
2. Ground surface.
3. Calculated batholith roof. The intrusion is shaded.
● Calculated values of the magnetic anomaly.

It is possible that the ridge-like anomaly, which has been interpreted as a ridge in the batholith roof, may be associated with and produced by the tuffs of (?) Jurassic age exposed at Koerner Rock. These rocks have a remanent magnetization with an intensity of $1,890 \times 10^{-6}$ c.g.s. units and a direction of 22° **UP** with an azimuth of 293° east of magnetic north. There is some suggestion of instability in the large standard deviation of this remanent magnetization (Table III), and the wide variation in magnetic properties makes interpretation of the observed magnetic anomalies in terms of these tuffs inappropriate until further information has been obtained.

d. *Profile D.* This profile extends from 10·5 km. (6·5 miles) south-east of Mount Fidase to Andersson Nunatak (Fig. 5) and Fig. 9 gives the section of the batholith roof obtained from an interpretation of the observed magnetic anomalies, using both vertical and horizontal polarizations of a resultant magnetization with an intensity of $3,515 \times 10^{-6}$ c.g.s. units in the direction of the Earth's magnetic field. At the western end of the profile, in the area of Camel Nunataks, the batholith roof is 4·0 km. (2·5 miles) below surface, whilst at the eastern end, near Andersson Nunatak, it has a depth of 2·3 km. (1·4 miles). The batholith roof reaches its maximum elevation to the north of Twin Peaks, where it has a depth of 350 m. (1,150 ft.) below the surface. The intensity of magnetization measured from samples collected at Blade Ridge has been used for the interpretation of this profile, and it is possible that differentiation of the rocks of the Andean Intrusive Suite in the Andersson Nunatak area could lead to substantial errors of interpretation here.

e. *Errors of interpretation resulting from changes of magnetization.* The magnetic anomalies have been interpreted in terms of the topographic variations in the roof of the Andean Intrusive Suite batholith. It has been assumed during the interpretation of profiles A, B and D that the intensity of polarization or magnetization of the intrusive rocks is constant at $4,060 \times 10^{-6}$ c.g.s. units and that the observed magnetic anomalies are the expression of topographic variations in the batholith roof rather than of polarization changes in the intrusive rocks. The interpretation of polarization anomalies as topographic anomalies can lead to substantial errors, and the magnitude of these errors can be estimated by calculation of the magnetic anomalies produced by different polarizations of a simple geometrical model.

A two-dimensional prism, with a finite width of 5 km. (3·1 miles) and with the other horizontal dimension infinite, but with a variable but finite depth to its top surface, can be used as a model. The anomalies produced by this model (whose bottom surface is infinitely deep) have been calculated for depths of the top surface of the prism between 1 and 5 km. (0·6 and 3·1 miles) and for intensities of vertical magnetization of 4,060 and $4,920 \times 10^{-6}$ c.g.s. units. The errors in the determination of the depth of the batholith roof, which may result from a misinterpretation of polarization anomalies, vary from 65 to 25 per cent for depths of 1 and 5 km. (0·6 and 3·1 miles), respectively. Although these errors are only applicable to the particular model used for the calculations, they do give some indication of possible errors which may result from unseen variations in the intensity of magnetization. The magnitude of the errors in the interpretation, which may be caused by unseen variations in the polarization or magnetization, will depend on the areal extent and magnitude of these changes and the effects of horizontal polarization which have not been considered in the approximate calculations discussed above.

Although some of the details of the interpretation may be in error, the consistency of the results of the application of different interpretation methods to the magnetic anomalies in the Mott Snowfield and Misty Pass areas (p. 23–24) indicates that the broader and more important aspects of the interpretation may be substantially correct.

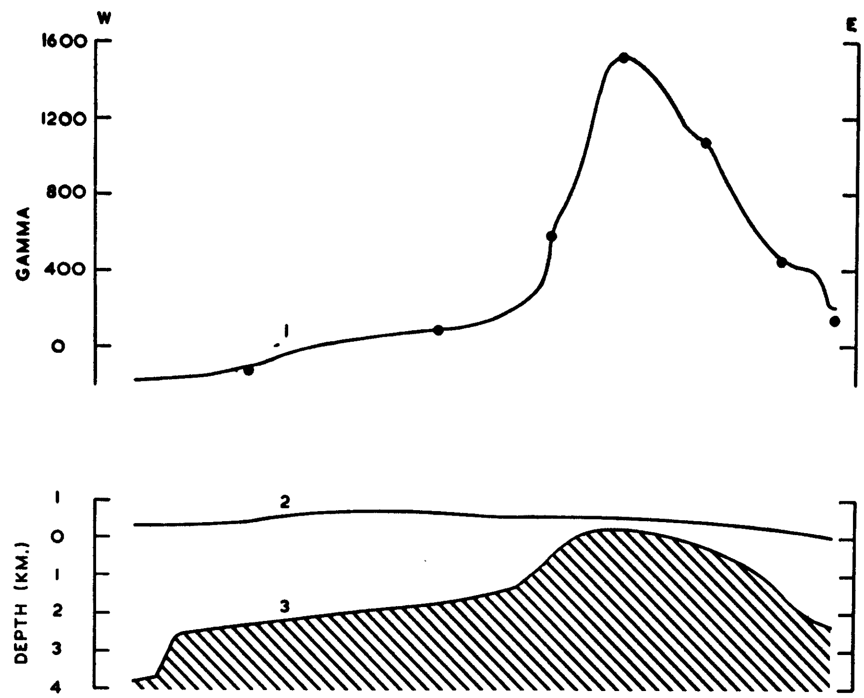

FIGURE 9

Profile D for the solution of the intrusion anomaly.
1. Observed magnetic anomaly.
2. Ground surface.
3. Calculated batholith roof. The intrusion is shaded.
● Calculated values of the magnetic anomaly.

5. *Topography of the batholith roof in the Marescot Ridge—Cape Roquemaurel area*

The reliable interpretation of the observed anomalies in this area is hampered by the differentiation of the Andean Intrusive Suite into rocks with wide variations in magnetic properties. The samples collected from west of Thanaron Point have a resultant intensity of magnetization of $3,130 \times 10^{-6}$ c.g.s. units (azimuth 353° east of magnetic north, inclination 55° UP), which is similar to that of the diorites and quartz-gabbros of north-east Trinity Peninsula. However, the Andean Intrusive Suite occurs as a more acid differentiate 1·25 miles (2 km.) north-west of Crown Peak and at Wimple Dome, where the resultant magnetizations are small (690×10^{-6} c.g.s. units) and effectively zero, respectively. It is possible that the intrusion 1·25 miles (2 km.) north-west of Crown Peak is a marginal facies of the Andean Intrusive Suite batholith, because of the vugs and coarse patches which are apparent in the hand specimen and the mineralogy of the rock in thin section (personal communication from D. H. Elliot). The magnetic anomalies mapped to the south of Thanaron Point, which are similar in magnitude to those of north-east Trinity Peninsula, probably indicate that they are produced by rocks of similar magnetic properties to those of the rocks at Thanaron Point. Profile E (Fig. 10) has been drawn in an approximate north—south direction, and the anomalies in this area have been interpreted in terms of the resultant intensity of magnetization of the rocks at Thanaron Point. The calculated depths of the batholith roof are respectively 3·0 and 0·5 km. (1·9 and 0·3 miles) below surface at the northern and southern ends of the profile.

No interpretation of the anomalies between Wimple Dome and Cape Roquemaurel has been attempted, because of the probable large changes in the magnetic properties of the rocks in this area.

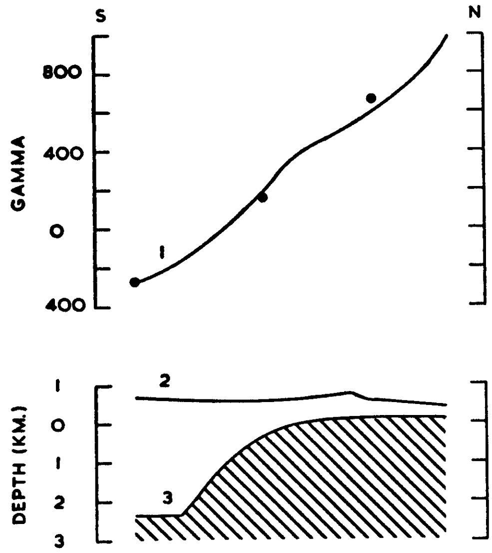

FIGURE 10

Profile E for the solution of the intrusion anomaly.
1. **Observed magnetic anomaly.**
2. **Ground surface.**
3. **Calculated batholith roof. The intrusion is shaded.**
● **Calculated values of the magnetic anomaly.**

6. *Structure at Misty Pass*

The change in the trend of the magnetic anomalies in the Misty Pass area from south-west—north-east to north-west—south-east is probably due to some structural feature. A three-dimensional interpretation of the anomalies in this area is hampered by this change in anomaly trend and a two-dimensional interpretation has therefore been used as an approximation. Calculations based on the gradients of the anomalies along profile F suggest that a change in the topography of the batholith roof at a depth of about 5 km. (3·1 miles) could produce the observed anomalies. If the intrusive rocks are assumed to have an intensity of magnetization ($4{,}060 \times 10^{-6}$ c.g.s. units) similar to that of the Andean Intrusive Suite in the Mott Snowfield area, then a more exact fit of the calculated anomalies to the observed anomalies can be accomplished by using a precise mathematical expression for the magnetic effect for a fault or scarp subject to both horizontal and vertical polarizations. In Fig. 11 (curve 2) the best calculated fit to the observed anomalies (curve 1) was obtained from a model of a scarp or fault with a downthrow of 1 km. (0·6 miles) to the north-east with a dip of 60°. Curves 3 and 4 (Fig. 11) were obtained from models of faults or scarps with throws of 1·4 and 1·0 km. (0·9 and 0·6 miles) and dips of 60° and 45°, respectively. The depth to the centre of the fault or scarp structure for all models was 4·5 km. (2·8 miles) below a surface of elevation ranging from 2,000 to 3,000 ft. (656 to 984 m.) above sea-level. Although the observed anomalies might also be explained in terms of a change in the magnetic properties of the rocks of the Andean Intrusive Suite, the similarity between the depths of the batholith roof calculated by different methods from the observed anomalies in the Misty Pass and Mount Fidase areas is a substantiation of the consistency of interpretation.

The pronounced dynamic metamorphism of the Trinity Peninsula Series rocks near Misty Pass (Elliot, 1965), the over-deepened nature of Misty Pass itself, and the parallelism of the postulated structural feature at Misty Pass with the north-west to south-east trends in the Mott Snowfield area, substantiate the interpretation of the magnetic anomalies in the Misty Pass area.

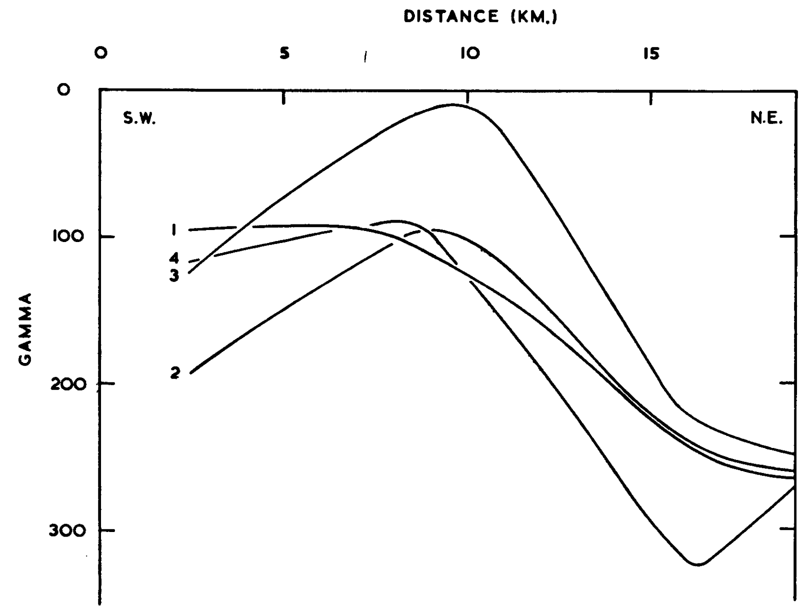

FIGURE 11

The anomaly in the Misty Pass area (Map 1).

1. Observed magnetic anomaly.
2. Calculated magnetic anomaly for a fault with a 1 km. (0·6 miles) downthrow to the north-east and a dip of 60°.
3. Calculated magnetic anomaly for a fault with a 1·4 km. (0·85 miles) downthrow to the north-east and a dip of 60°.
4. Calculated magnetic anomaly for a fault with a 1 km. (0·6 miles) downthrow to the north-east and a dip of 45°.

7. *Structure at Prime Head and its relation to possible structural trends along the north coast of Trinity Peninsula*

The rock forming two small nunataks at Prime Head is a porphyritic andesite (personal communication from D. H. Elliot), which is volcanic in origin and probably Cretaceous in age. These outcrops occur at the end of a narrow snow ridge sloping down to the sea and, although severe crevassing on either side of the ridge has prevented survey in these areas, the profile surveyed along the ridge has indicated that this rock has only a very local extent. A probably similar outcrop of these rocks has been observed by Halpern (1964) near Cape Legoupil; the isolated occurrence of these rocks along the north coast of Trinity Peninsula is interpreted later as an indication of structural control.

The extrapolation of the contours on Fig. 5 gives a very approximate depth of about 2 km. (1·2 miles) for the depth of the batholith roof in the Prime Head area. The strike and magnitude of the depth contours of the batholith roof here indicate that the anomalies associated with the rocks of the Andean Intrusive Suite are of relatively minor importance in comparison with the steep anomalies produced by the contact between the andesitic rocks and the rocks south of Prime Head. The Trinity Peninsula Series is exposed a few miles east of Prime Head and it is suggested that these rocks are in contact with the andesitic lava flows south of Prime Head.

The observed anomalies have been interpreted in terms of a steeply dipping contact between the volcanic rocks of Prime Head and the Trinity Peninsula Series, using an intensity of magnetization of $2{,}100 \times 10^{-6}$ c.g.s. units (inclination 70° UP, azimuth 6° east of magnetic north) for the andesitic rocks. Calculation of the vertical field magnetic anomalies produced by both horizontal and vertical polarizations gave a contact with a dip of 60° extending to a depth of 3 km. (1·9 miles). The upper surface of the contact was assumed to underlie the 1,800 gamma contour about 0·5 km. (0·3 miles) south-west of Prime Head (Map 2). A depth of 3 km. (1·9 miles) to the lower surface of the andesitic rocks contradicts the very approximate depth of 2 km. (1·2 miles) for the batholith roof in this area and serves to indicate both the possible uncertainties in the interpretation of the Prime Head anomalies and the approximate nature of the batholith roof contours at any great distance from the computed profiles. Nevertheless, any interpretation must indicate the very local extent of the andesitic volcanic rocks on the north coast of Trinity Peninsula. Halpern (1964) has observed faulting with an approximate trend of south-west to north-east in the Cape Legoupil area, and it is suggested faulting might also explain the limited occurrence of andesitic rocks at Prime Head. In this case the volcanic rocks would be down-thrown to the north against the rocks of the Trinity Peninsula Series, and the trend of the fault along the north coast would be parallel to possible faulting observed by Bibby (1966) along the south-east coast of Trinity Peninsula (p. 27).

8. *Possible transcurrent fault at Hope Bay*

The magnetic survey in the Hope Bay area was carried out with a station spacing which was often large in comparison with the considerable geological variations in this area. The complexity of the geology of the Hope Bay area (Fig. 12), in which the Trinity Peninsula Series, Jurassic sedimentary and volcanic

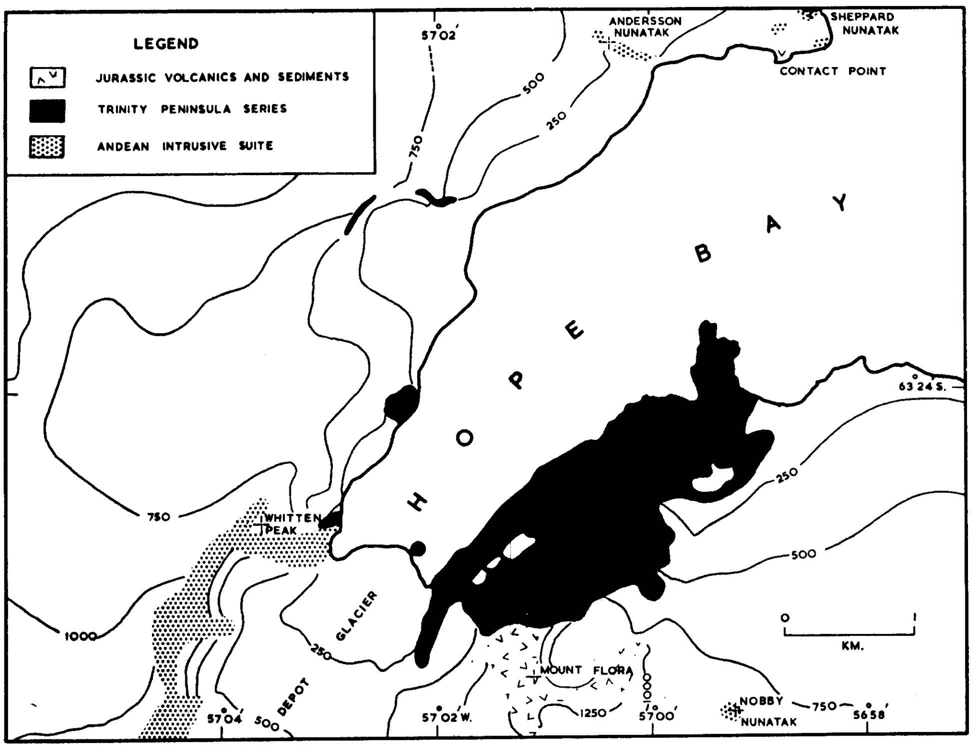

FIGURE 12

Sketch map showing the geology and topography of the Hope Bay area. Contours are at intervals of 250 ft. (76 m.).

rocks, and the Andean Intrusive Suite are exposed, must restrict magnetic survey to a small station spacing, if the detailed anomalies in the area are to be accurately defined. Consequently, the relatively large station spacing used to obtain the anomaly map (Fig. 13) can only give an indication of some of the broader geological variations in this area.

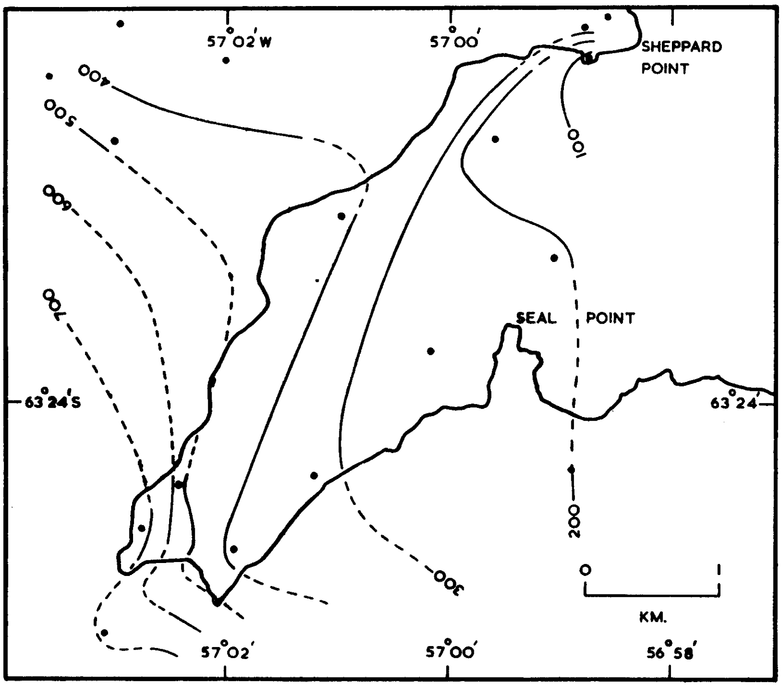

FIGURE 13

Magnetic anomalies in the Hope Bay area. The contours are at 100 gamma intervals and they show the greater extension of the high anomaly contours to the north-east on the north-west side of Hope Bay.

The anomaly map (Fig. 13) shows that the high anomaly contours extend farther eastward on the north side of Hope Bay than on the south, and this may indicate that rocks of the Andean Intrusive Suite (probably similar to those of Blade Ridge) may also extend farther on the northern side. Physiographically, it is clear that the linearity of the trends of Hope Bay and Depot and Mondor Glaciers may be indicative of some structural trend along their common axis. It could be that transcurrent faulting has been responsible for the postulated relative displacement of the rocks of the Andean Intrusive Suite at Hope Bay. There is no significant geological information which might corroborate the possibility of transcurrent faulting, although Croft (1947) has observed some horizontal movement along a minor fault, the trend of which is different from that of the proposed structural feature. It may be significant that the sense of the faulting postulated between Cape Legoupil and the isthmus south of Cape Ducorps (Halpern, 1964) is the same as that postulated at Hope Bay. These postulated transcurrent faults are discussed on p. 31 with reference to movement of the Antarctic Peninsula and Antarctica during continental drift (Allen, 1966).

9. *James Ross Island Volcanic Group in Broad Valley*

Tuffaceous agglomerates of the James Ross Island Volcanic Group form Cain Nunatak in the lower reaches of Broad Valley, and they are also thought to occur at the nearby but inaccessible Abel Nunatak. Although Cain Nunatak and the area immediately to the west have been surveyed, crevasses prevented survey to the north, east and south. The negative anomalies observed in the Cain Nunatak area cannot possibly be produced by the tuffaceous agglomerates, since their magnetization and the magnetizations of all the tuffaceous agglomerates in the area surveyed are too small and possess the wrong direction of remanence. The anomaly centred on Cain Nunatak is negative with respect to the ambient magnetic field in Broad Valley, and an intensity of at least 400×10^{-6} c.g.s. units must be inferred for the reversed resultant magnetization producing the anomaly. If a reversely magnetized volcanic plug or series of lava flows, with an intensity of remanent magnetization similar to that of the samples collected by Ashley (1962), was present beneath the exposed tuffaceous agglomerates, then either might account for the observed anomalies.

N. Aitkenhead (personal communication) has observed that the tuffaceous agglomerates at Cain Nunatak have dips which are indicative of a local eruptive centre, and it would therefore seem that the observed anomalies can best be attributed to a volcanic plug rather than to a series of lava flows of more distant origin. The unusual occurrence of rocks of the James Ross Island Volcanic Group on the north-west side of Prince Gustav Channel might be explained by a zone of weakness, associated with the extension of the fault at Misty Pass, which has favoured the extrusion of volcanic rocks in this area.

10. *Jurassic rocks of Bald Head, Crystal Hill and Camp Hill*

A sequence of Jurassic andesitic rocks rests unconformably on the Trinity Peninsula Series at Bald Head (Fig. 14), but farther to the west at Crystal Hill the entire headland is composed of rhyolitic rocks (Bibby,

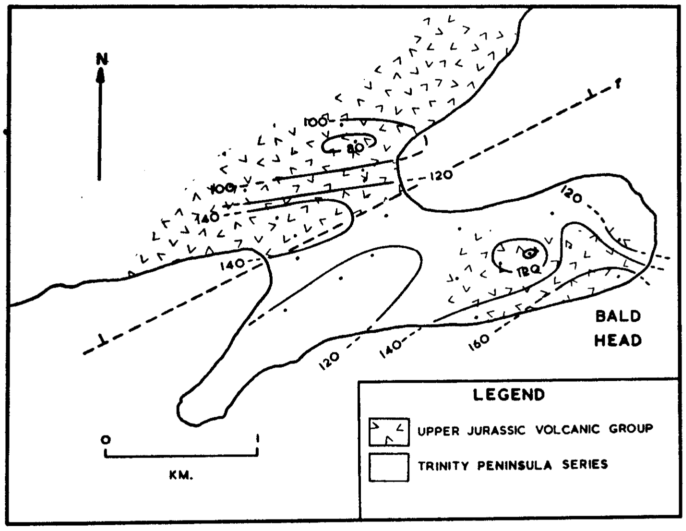

FIGURE 14

Sketch map showing the geology and magnetic anomalies in the Bald Head area. All anomalies are negative and the contour interval is 20 gamma. Magnetic survey stations are shown as dots. Geology after Bibby (1966).

1966). The intensity of remanent magnetization of the rocks exposed at Bald Head has been measured as 200×10^{-6} c.g.s. units (inclination 66° UP, azimuth 71° east of magnetic north). The areas of minimum negative anomaly occur where andesitic rocks have been observed by Bibby (1966), who has postulated that a fault with a downthrow to the north may pass through the col north of Bald Head. Although the magnetic survey has given some substantiation to the areal extent of the andesitic rocks, it cannot be used to provide independent evidence for the existence of this fault.

Bibby (1966) has found a disturbed zone in the outcrops on the west side of Crystal Hill, where an abrupt change in the lithology of the Jurassic rhyolitic rocks led him to postulate a fault with a throw to the south. The low magnetic properties of the rocks in this area rendered magnetic survey of little value and only a few magnetic stations were positioned in this area.

A detailed magnetic survey was carried out over the Camp Hill peninsula (Fig. 15) but only small magnetic anomalies were mapped, because of the low magnetic properties of most of the rocks in the area. Both the rhyolitic dyke at Striped Hill and the Middle Jurassic sediments exposed over the peninsula have negligible magnetizations. The Jurassic extrusive and intrusive rocks towards the eastern end of the peninsula have significant intensities of magnetization (Tables III and IV) and their associated anomalies are shown in Fig. 15. The Jurassic intrusion has an associated anomaly of about 300 gamma, whereas the anomalies associated with the extrusive rocks are only about 25 gamma. Both the intrusive and extrusive rocks are andesitic in composition and the difference in the magnitude of their associated anomalies is probably indicative of the small thickness of the andesitic flows at the eastern end of the peninsula. The minor geological significance and doubtful reliability of additional interpretation of the magnetic anomalies in this area makes further comment inappropriate.

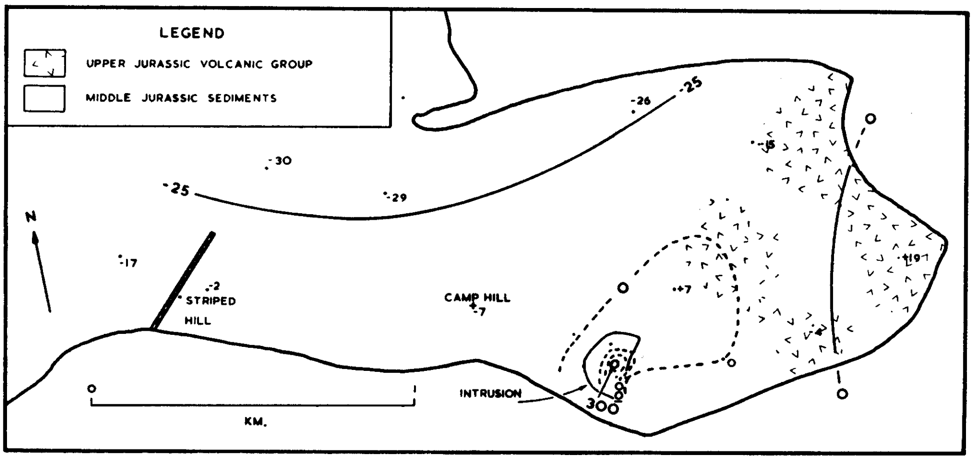

FIGURE 15

Sketch map showing the geology and magnetic anomalies in the Camp Hill area. Contours are in gammas as indicated. Geology after Bibby (1966).

11. *James Ross Island Volcanic Group*

a. *General observations.* The rocks of the James Ross Island Volcanic Group comprise most of the islands in Prince Gustav Channel and they also occur on James Ross and Vega Islands, where they rest unconformably on Cretaceous sediments. These volcanic rocks include subaqueous and subaerial tuffs, tuffaceous agglomerates, and basaltic lavas and dykes. Nelson (1966) has observed numerous small dykes on Beak, Eagle, Vortex, Tail and Carlson Islands with a lineation most commonly parallel to Prince Gustav Channel but sometimes at high angles to it.

These rocks exhibit great variations in magnetic properties; the tuffs and tuffaceous agglomerates have low or negligible magnetizations, whereas the basaltic lavas and dykes are generally strongly magnetized. Some of the dykes of this group are rich in accessory iron ore minerals (Nelson, 1966), which no doubt accounts for some of the large intensities of remanent magnetization (Table III) determined for the dykes of Tail Island. The great variations in the magnetic properties of the different rocks of the James Ross Island Volcanic Group make the interpretation of the magnetic survey difficult in comparison with the interpretation of magnetic anomalies produced by the Andean Intrusive Suite of north-east Trinity Peninsula.

In the area between the north coasts of James Ross and Vega Islands and the islands in Prince Gustav Channel, the presence of positive and negative anomalies of moderate gradient suggests that the rocks of the James Ross Island Volcanic Group occur on or below the sea bed. The gradient of anomalies between Red and Vortex Islands indicates that these anomalies have a source at a depth of several hundred fathoms, and a sea depth of about 400 fathoms (732 m.) is consistent with the submarine occurrence of these rocks in this area.

The anomalies in the area north of Vega Island have a magnitude similar to that measured off the north coast of James Ross Island near Brandy Bay, where Cretaceous sediments are exposed. The anomalies in these areas have very low gradients, indicating that rocks of similar magnetic properties to those of the sea floor between Vortex and Red Islands are absent, and that the sea floor north of Vega Island is composed of Cretaceous sediments or James Ross Island Volcanic Group tuffs or tuffaceous agglomerates of low intensity of magnetization.

Approximately 300 ft. (91·4 m.) of lava flows with their base at 300 ft. (91·4 m.) above sea-level are exposed in the cliffs at and near Keltie Head (personal communication from P. H. H. Nelson). The height of the ice dome south-east of Keltie Head is 1,300 ft. (396 m.), so that the thickness of the series of lava flows might be several hundred feet in excess of the thickness exposed in the cliffs. If a reasonable ice thickness of 100 ft. (30·5 m.) and an elevation of 1,200 ft. (366 m.) for the upper surface of the lava flows are assumed, then a disc of lava flows with a radius of 1 km. (0·6 miles) and a vertical intensity of magnetization of 5×10^{-3} c.g.s. units would produce an anomaly of 900 gamma. Clearly, if the intensity of magnetization were increased to 8×10^{-3} c.g.s. units or the dimensions of the model were altered slightly, the calculated anomaly would approximately agree with the observed anomaly of 1,400 gamma. Although these approximate calculations of vertical field magnetic anomalies have been made only for vertical polarization, they suggest that the thickness of the series of lava flows might be greater than that exposed in the cliffs, if the observed anomalies are to be explained by the assumption of an intensity of magnetization similar to that measured for the lava flows in this area (Tables III and IV).

b. *Tail Island.* The magnetic anomalies on and in the vicinity of Tail Island reach their maxima in the coastal areas before they decrease rapidly towards the centre of the island. The station spacing of the magnetic survey, although no more than adequate for the mapping of the great anomaly variations in this area, indicates the large-scale features of the anomaly map (Fig. 16). Subaerial tuffs comprise most of the outcrops on the island but there are some outcrops of subaqueous tuffs along the east and west

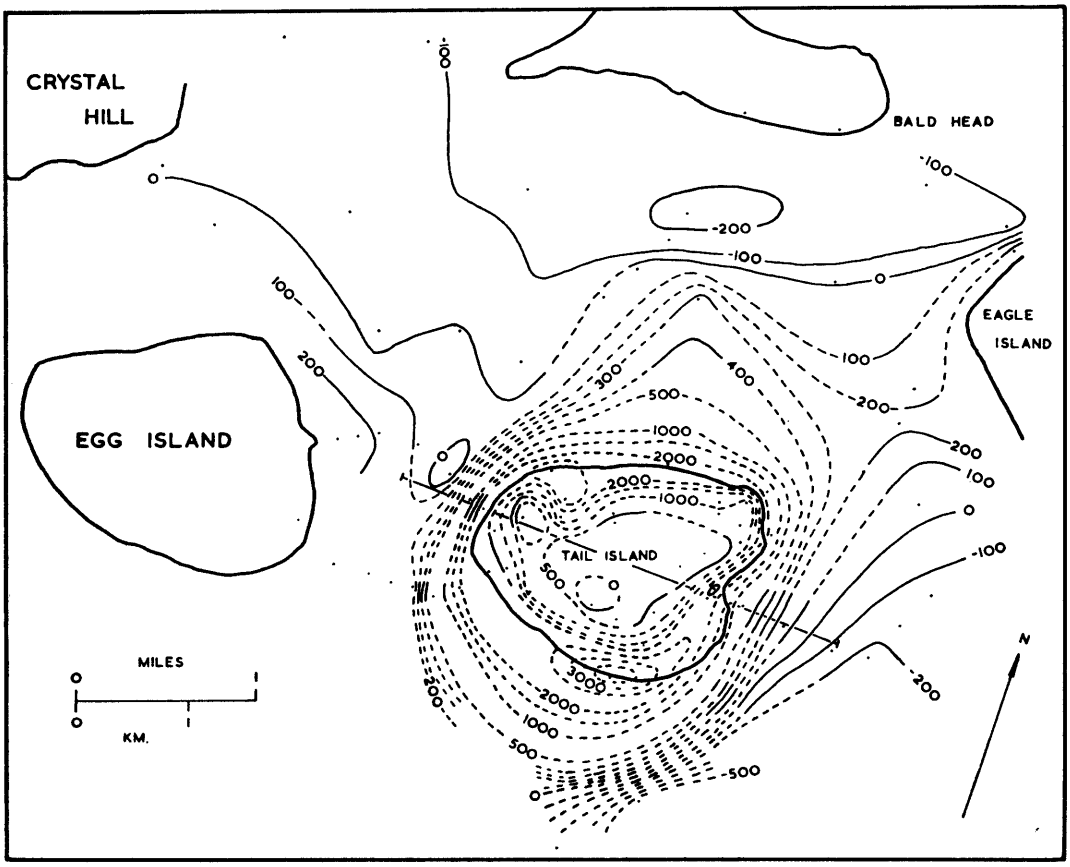

FIGURE 16

Sketch map showing the magnetic anomalies in the area around Tail Island. Contours are in gammas as indicated. Magnetic survey stations are shown as dots. A profile across Tail Island is shown (Fig. 17).

coasts. Numerous dykes a few feet in width intrude both types of tuff in the low cliffs around the coast and they are typical of those observed on other islands in Prince Gustav Channel (Nelson, 1966). These dykes are the only significantly magnetic rocks on the island and they have a remanent magnetization with an intensity of $12{,}380\times10^{-6}$ c.g.s. units and a relatively small susceptibility of 180×10^{-6} c.g.s. units (Tables III and IV).

The observed anomalies are best explained in terms of a circular annulus, which is roughly coincident with the coastline of the island. The anomalies are almost symmetrical (Fig. 17) and the direction of remanent magnetization (inclination 72° UP, azimuth 319° east of magnetic north) indicates the approximately vertical extension in depth of the magnetic body producing the anomalies. An annulus with an approximately vertical axis is a more feasible model than a substantial thickness of lava flows, since calculations of the thickness of the latter model from the magnitude of the observed anomalies give a thickness too great to be consistent with the gradients of the observed anomalies. It is difficult to give a reliable estimate of the thickness of the sides of the annular model, because of the presence of dyke swarms in this area, but an estimate might be several tens of metres. It is envisaged that the dyke swarms originate from the top of the shallow annulus. If the observed anomalies were not explained in terms of an approximately circular annulus, it would be difficult to account for the consistently high magnetic anomalies observed round the cliffs and coastline of the island in terms of a random complex of dykes. It is therefore suggested that the postulate of an approximately circular annular body, with vertical sides several tens of metres in thickness, is the best tentative explanation of the available data. In geological terms, it is suggested that a ring-dyke system coincides with the coastal cliffs of Tail Island. Both the coastal cliffs and the concave topography of the central part of the island are expressions of the differing resistances to erosion of the coastal dyke rocks and the inland tuffs.

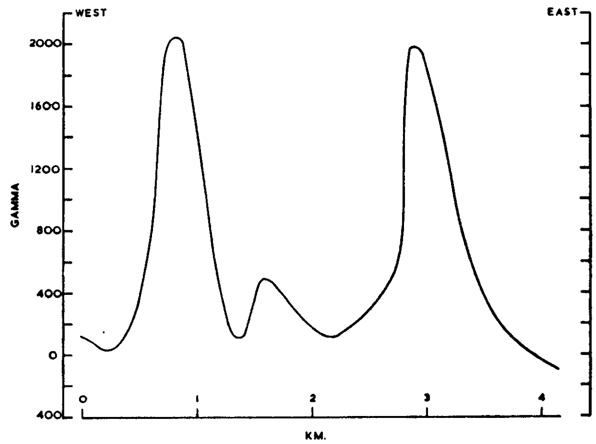

FIGURE 17
Magnetic anomalies across Tail Island along the profile shown in Fig. 16.

VII. SUMMARY

THE fundamental assumption of the widespread existence of a batholith of the Andean Intrusive Suite beneath north-east Trinity Peninsula has been used for much of the interpretation of the magnetic survey of this area. The similarities between the intrusive rocks of Graham Land and those of the South American Andes, the high anomaly area in Mott Snowfield which is indicative of the large areal extent of these rocks, and the consistency between the results of different methods of the interpretation of different anomalies all substantiate this assumption.

The interpretation of the topographic variations in the Andean batholith roof has led to postulating north-west to south-east trending structural features, which cross Trinity Peninsula at Misty Pass and in the Mott Snowfield area. These structural features are probably faults, which were associated with the emplacement of the Andean Intrusive Suite and subsequent uplift and block faulting. Faults along the north-west and south-east coasts of Trinity Peninsula, although partly inferred from physiographic evidence and the limited occurrence of Jurassic and Cretaceous rocks, are also substantiated by the field observations of Halpern (1964) and Bibby (1966). Similar trends of structural lineation have been observed by Barton (1965) at King George Island north of Bransfield Strait. The Department of Geology, University of Birmingham, has confirmed a major south-west to north-east structural feature south of the South Shetland Islands, using seismic refraction methods and detailed studies of submarine topography.

Gravity anomalies, although based on a few stations along the north and east coasts of north-east Trinity Peninsula, corroborate the postulated north-west to south-east trending structural feature in north-east Trinity Peninsula. Bouguer anomalies in the Bransfield Strait area (Griffiths and others, 1964, fig. 19) have a strike which changes from south-west—north-east to north-west—south-east near Laclavère Plateau. Although no gravity observations have been made in the interior of Trinity Peninsula, this change in strike appears to be approximately delineated, and it can be explained in terms of the density contrast between rocks of the Andean Intrusive Suite and those of the Trinity Peninsula Series, whose respective average densities have been determined as 2·76 and 2·67 g./cm.^{3} in or near Mott Snowfield. Rough calculations show that the change in strike of the gravity anomalies could be produced by doming of the batholith roof as already interpreted from the magnetic survey of the Mott Snowfield area.

The inclination (60° UP) of the mean direction of remanent magnetization of the samples of the Andean Intrusive Suite (p. 14) collected in the central and northern parts of north-east Trinity Peninsula is lower than that of the samples collected by Ashley (1962) on Tabarin Peninsula. If Bransfield Strait is a graben, and a substantial fault with a northerly downthrow has been interpreted from the magnetic survey at Prime Head (p. 24–25), then it may be that the low inclination of remanent magnetization can be explained by a rotation of Trinity Peninsula along a south-west to north-east axis, which occurred at the same time as the formation of Bransfield Strait but after the emplacement of the Andean Intrusive Suite.

Interpretation of the magnetic anomalies associated with the James Ross Island Volcanic Group has been largely restricted to qualitative observations on the occurrence of these rocks and to the postulate of a ring-dyke system on Tail Island (p. 29–30). The isolated occurrence of tuffs and agglomerates in Broad Valley, north-west of Prince Gustav Channel, may be associated with an extension of the fault postulated at Misty Pass (p. 23–24).

Halpern (1964) has observed faulting along the north-west coast of Trinity Peninsula at Cape Legoupil and a transcurrent fault may exist at Hope Bay (p. 25–26). Allen (1966) has explained the present position of the Antarctic Peninsula in terms of a westward drift of Antarctica; the tectonic system observed in north-east Trinity Peninsula and the South Orkney Islands (Adie, 1964) could be consistent with drift in this direction.

VIII. ACKNOWLEDGEMENTS

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